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ORIGINAL

Modal Interpolation Program, L 215 (INTERP)

Volume I: Engineering and Usage

R. I. Kroll and M. Y. Hirayama

CONTRACT NAS1-13918
OCTOBER 1979

NASA

122

NASA Contractor Report 2847

Modal Interpolation Program, L 215 (INTERP)

Volume I: Engineering and Usage

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Prepared for
Langley Research Center
under Contract NAS1-13918

National Aeronautics
and Space Administration

Scientific and Technical
Information Branch

1979

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1.0 SUMMARY

The program L215 (INTERP) is a modal interpolation program designed to determine specific motions at desired aerodynamic control points. The motions obtainable are translations normal to the surface and surface slopes, which are parallel and perpendicular to the freestream direction.

The program performs the interpolation process in two stages. First, using the modal data generated by a vibration analysis, a set of interpolation coefficient arrays (SA arrays) are formed. Second, the SA arrays are used with aerodynamic control-point geometry data, to calculate the needed surface motions at the control-point locations. Either phase may be executed separately, with the data saved from each phase on a magnetic file (tape or disk) for later use.

Modal data consists of nodal locations and nodal displacements that describe the shape of each vibrational mode (mode shape). This data can be subdivided and rearranged to best meet the user's needs. Nodal locations may be input in reference axis or local axis system coordinates. Mode shape data can be input in combined freedom form (one matrix containing all allowed nodal displacements) or in single freedom form (separate matrices with each matrix containing a specific type of displacement for all nodes) and the number of modes can be reduced or increased as desired. Modes describing rigid control surface rotations can be added to the basic set of input modes.

Five types of interpolation methods are available for use: motion point, motion axis, beam spline, surface spline, and polynomial. Care must be exercised in matching the type of modal input and the desired use of the interpolated motion with the type of interpolation method chosen.

The only theoretical assumption made in the interpolation program is that all displacements described by the mode shapes are defined in the local aerodynamic surface. No displacement transformations are applied to the input mode shapes.

The output from L215 consists of:

- Sorted input mode shapes and node locations
- SA arrays
- Interpolated displacements consisting of surface translations and slopes

The significant program restrictions are:

- All interpolated slopes are given parallel and/or perpendicular to the freestream direction.
- The beam spline interpolation method will yield slopes perpendicular to the freestream direction only if mode shapes for the beams contain these displacements.
- Problem size for any one surface is governed by the SA array size limitation of 10 000 words.

2.0 INTRODUCTION

The computer program L215 (INTERP) was developed for use either as a standalone program or as a module of the program system called DYLOFLEX developed for NASA under the contract NAS1-13918 (ref. 1). The modal interpolation program (L215) was designed to meet the DYLOFLEX contract requirements as defined in reference 2. These requirements specify the need for a program capable of calculating displacements at several points on an aerodynamic surface from modal data generated in a structural vibration analysis. The program was developed using existing BCAC/BCS interpolation subroutines.[1]

The objective of this volume is to aid those persons wishing to use the program. To meet this objective, the following items are discussed:

- The engineering and mathematical equations used to formulate the problem
- Program structure and design
- Guidelines to the actual use of the program.

A sample problem is also presented in this volume to aid the user in the execution of the program.

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[1] *ATLAS - An Integrated Structural Analysis and Design System* "System Design Document," D6-25400-0002TN, and "User's Manual - Input and Execution Data," D6-25400-0003TN. Boeing Commercial Airplane Company, 1974.

3.0 SYMBOLS AND ABBREVIATIONS

Below is a list of items that appear in the discussion of this document except section 6.5.1 (card input)..

Engineering Notation	Definition
C_{ij}	Coefficients used for the polynomial interpolation method.
C_0, C_1, C_2, C_3	Coefficients of the cubic function used in the cubic spline techniques.
$d\delta_z/dx$	Surface slope parallel to the freestream direction.
$d\delta_z/dy$	Surface slope perpendicular to the freestream direction.
LAS	Local axis system.
N	Number of nodes used for interpolation.
n	Highest order of the polynomial function used for the polynomial interpolation method.
$\hat{n}$	Unit normal.
R	Perpendicular distance from the control surface hinge line to the point of interest on the control surface.
[R]	Euler rotation matrix.
RAS	Reference axis system.
r_i	Radial distance from the ith node on the surface to a point of interest on the surface.
Δr	Distance from the attachment point on the motion axis to the output point (measured positive for output points forward of the motion axis).
Sk	Smoothing factor for surface spline.
x_ℓ, y_ℓ, z_ℓ	Local axis system coordinates of a point on the surface.
$x_{H_{L_1}}, y_{H_{L_1}}$	Coordinates of the inboard end of the control surface hinge line.
x_{H_O}, y_{H_O}	Coordinates of the outboard end of the control surface hinge line.
XO_R, YO_R, ZO_R	Reference axis system coordinates of the local axis system origin.

X_R, Y_R, Z_R	Reference axis system coordinates at a point.
$x_{\ell_o}, y_{\ell_o}, z_{\ell_o}$	Local axis system coordinates of an output point.
$x_{\ell_n}, y_{\ell_n}, z_{\ell_n}$	Local axis system coordinates of a node point.
$\Delta x_\ell, \Delta y_\ell, \Delta z_\ell$	Offset distances between the node point and the output point (defined in the local axis system).
$x_{\ell_s}, y_{\ell_s}, z_{\ell_s}$	Local structural axis system coordinates of a point.
$\Delta x_{SH}, \Delta y_{SH}$	The desired x and y shift between the local structural axis system and the local aerodynamic axis system. (OFFX,OFFY) are the variables used inside the program.
$\delta_x, \delta_y, \delta_z$	Nodal translational displacements defined in the x,y,z direction.
$\delta_{z_r}, \theta_{x_r}, \theta_{y_r}$	Displacements at the motion axis reference points.
$\delta_{z_d}, \theta_{x_d}, \theta_{y_d}$	Dependent surface displacements.
$\delta_{z_p}, \theta_{x_p}, \theta_{y_p}$	Parent surface displacements.
$\theta_x, \theta_y, \theta_z$	Nodal rotational displacements defined about the x,y,z axes.
θ_{ℓ_H}	Rotation of the control surface about its hinge line.
$[\phi]$	Mode shape matrix.
ϕ, θ, ψ	Euler rotation angles.
γ	Desired dihedral correction to be applied to interpolated data.
γ_s	Surface dihedral angle
$\gamma_n^\wedge$	Unit normal orientation with respect to z reference axis in degrees.
Λ_r	Orientation angle of the attachment line used in the motion axis interpolation method.
Λ_H	Sweep angle of the control surface hinge line.
$a_1, \cdots a_N, a_{N+1}, a_{N+2}, a_{N+3}$	Coefficients for the surface spline interpolation function

4.0 ENGINEERING AND MATHEMATICAL DESCRIPTION

4.1 CONCEPT OF SURFACES

In finite-element-type aerodynamic methods, components such as flat plates used for lifting or thin body representations, bodies of revolution used for slender body representations, and polygonal cross-sectional cylinders used to represent interference bodies are employed in various combinations when aerodynamically modeling an airplane. The calculation of aerodynamic forces for each of these elements usually requires normal motions and freestream slopes at aerodynamic control points on the elements. It is often the case that vibration analyses, which can use modelings ranging from simple beams to complete finite element representations, calculate motions at nodal points that are not directly applicable to the aerodynamic modeling. Also, the aerodynamic idealization may often be varied without necessitating a change in the vibrational model. It is necessary, therefore, to be able to interpolate the modal data for the required motions at the aerodynamic control points.

In order to give the analyst the versatility of using a variety of vibrational analyses with various aerodynamic modelings, it is necessary to be able to regroup, rearrange, and reorder the modal data into subsets that best fit the chosen aerodynamic modeling. These subset divisions shall be called surfaces. It is not necessary to have a one-to-one correspondence between the modal subsets, or surfaces, and the aerodynamic bodies. For example, the modal data grouped into one set of surface data may be used to derive interpolation data for a slender body element and a related interference body element. On the other hand, two different surface groupings may be necessary to develop the interpolation data for a thin body that contains a movable control surface, or for a slender body that is capable of both vertical and lateral motions. User understanding of the aerodynamic modeling used and of the modal data being input, is required for proper surface divisioning.

4.2 AXIS SYSTEMS AND DISPLACEMENT SIGN CONVENTIONS

The interpolation program utilizes two basic types of axis systems, the reference axis system (RAS) and the local axis system (LAS). Both are right-hand systems.

Local axis systems are defined for each surface, and all the interpolation data that pertains to a surface is defined with respect to its local axis system. In defining a surface's local axis system, two rules must be followed:

- The local x axis must lie in the freestream direction with the positive x direction in the direction of the flow.
- The y axis must lie perpendicular to the flow with its positive direction pointing in the direction of increasing span.

The reference axis system is used to define the spatial relationships between the various surface local axis systems. Its function is purely geometrical, and it is advisable to maintain the same reference axis system throughout the analysis. A typical axis system orientation is shown in figure 1.

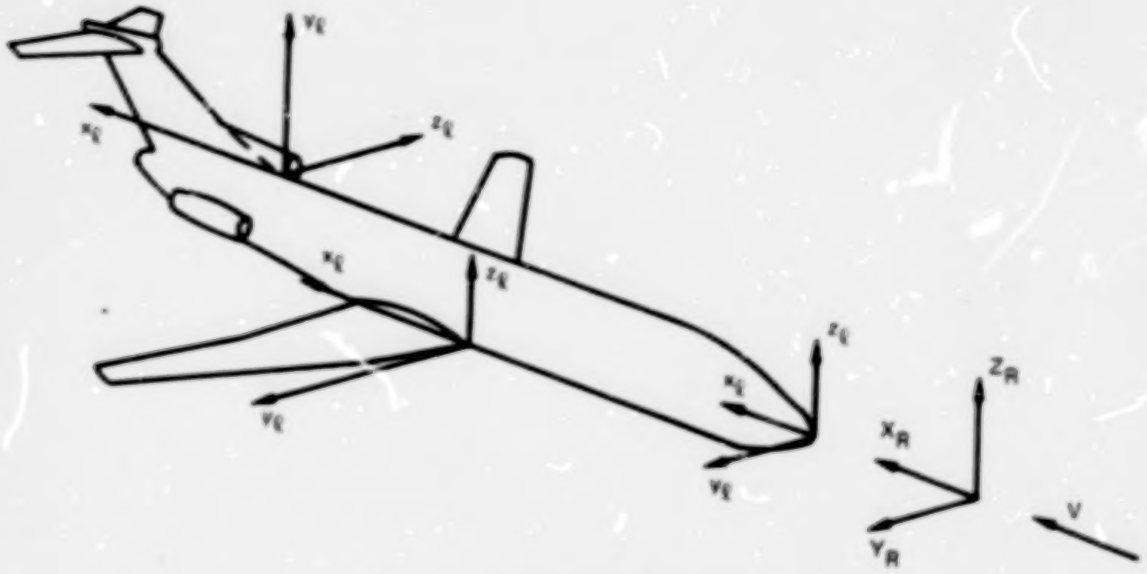

Figure 1.–Axis System Orientations

L215 (INTERP) assumes that for each interpolation surface the input modes used to formulate a surface's interpolation arrays are defined in the plane of the surface. For all interpolation methods, except motion axis, the input modes must be oriented in directions that are parallel and perpendicular to the freestream. The motion axis method can accept motion oriented perpendicular and parallel to local motion axis. The sign convention used by INTERP in forming the interpolation arrays is shown in figure 2. The ability does exist in INTERP to input modes defined in a sign convention different from that shown in figure 2.

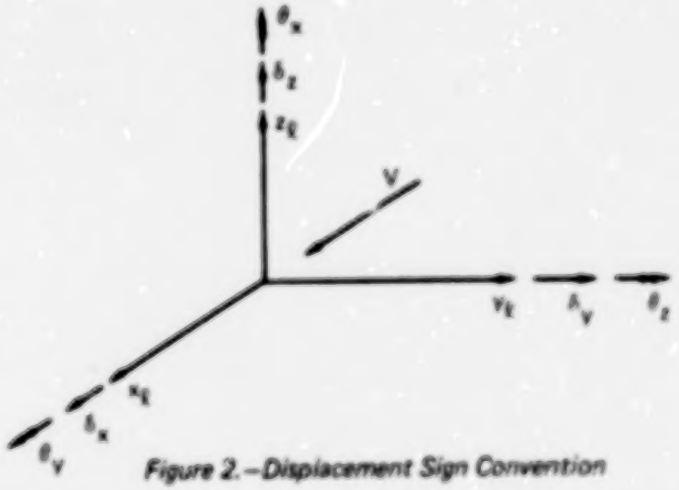

Figure 2.–Displacement Sign Convention

4.3 COORDINATE TRANSFORMATION

The location of any point can be expressed in reference or local axis coordinates. The transformation from one axis system to another is accomplished by applying the following transformation equation:

$$\begin{Bmatrix} x \\ y \\ z \end{Bmatrix}_{\ell} = [R] \begin{Bmatrix} X - XO \\ Y - YO \\ Z - ZO \end{Bmatrix}_{R} \tag{1}$$

where:

x_ℓ, y_ℓ, z_ℓ = Local axis system coordinates of a point in space

X_R, Y_R, Z_R = Corresponding reference axis system coordinates

XO_R, YO_R, ZO_R = Reference axis system coordinates of the origin of the local axis system

$[R]$ = Euler rotation matrix which rotates the reference axis system into the local axis system

The transformation described by equation (1) consists of a translation that moves the reference axis system to the origin of the local axis system and a rotation that rotates the translated reference axis system into the local system (see fig. 3).

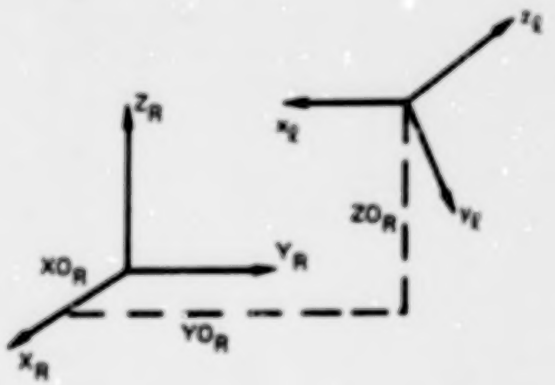

Figure 3.–Coordinate Transformation

The rotation matrix [R] is defined by performing one to three order-dependent rotations and is written as:

$$[R] = [R_3][R_2][R_1] \tag{2}$$

where $[R_i]$ = the ith rotation matrix about an axis. The subscript i signifies the order of rotation. The rotational matrices that describe the rotational transformation about any one axis are:

about the x axis:

$$[R_\phi] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\phi & \sin\phi \\ 0 & -\sin\phi & \cos\phi \end{bmatrix} \quad (3)$$

about the y axis:

$$[R_\theta] = \begin{bmatrix} \cos\theta & 0 & -\sin\theta \\ 0 & 1 & 0 \\ \sin\theta & 0 & \cos\theta \end{bmatrix} \quad (4)$$

about the z axis:

$$[R_\psi] = \begin{bmatrix} \cos\psi & \sin\psi & 0 \\ -\sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad (5)$$

Thus the rotation matrix in equation (2) is built up from the proper combination of the matricies given in equations (3) through (5). For example, for the rotation illustrated in figure 4 where the first rotation is about the y axis of the reference axis system, the second rotation is about the moved x axis, and the final rotation is about the z axis of the local axis system, the rotation matrix is given by:

$$[R] = [R_\psi][R_\phi][R_\theta] \quad (6)$$

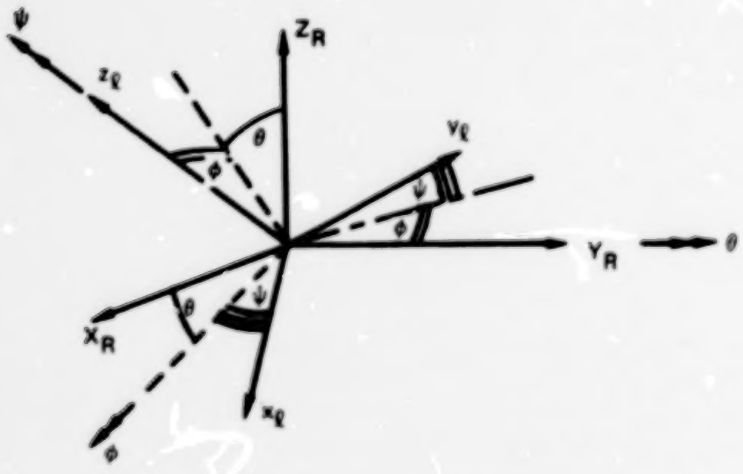

Figure 4.—Typical Rotational Transformation

A more detailed discussion of Euler angle definition can be found in reference 3.

The program places one restriction on the formation of equation (2). No two rotations may be about the same axis. One may not rotate first about the x axis, for example, then about the y axis, and finally about the x axis again. Rotations must take place about three different axes.

4.4 MODAL INTERPOLATION METHODS

The function of the interpolation program is to determine translations normal to an aerodynamic surface, and freestream slopes of the surface at points on the surface known as aerodynamic control points, from modal data generated by the user's vibrational analysis. The modal data consists of mode shapes and nodal coordinates.

The interpolation process is performed in two steps. First, nodal data, transformation data, and mode shape matrices $[\phi$'s$]$ for each surface are used to construct an array of interpolation coefficients called SA arrays. Second, the SA arrays for each surface are then used with the aerodynamic control-point locations for each surface to determine the translation normal to the surface, δ_Z, the surface slopes parallel to the freestream, $d\delta_Z/dx$, and the surface slopes perpendicular to the freestream, $d\delta_Z/dy$.

Five interpolation methods are available for use. All methods except one require mode shapes defined in the local axis system of the surface. The type of method chosen for a surface is dependent upon the type of vibration analysis performed (i.e., beam vs. finite element) and the type of aerodynamic body to which it will apply.

Table 1 lists some typical uses of the different interpolation methods. The selection of any one method for interpolation on a surface is left completely to the discretion of the analyst. Since the quality of interpolated results is affected by such factors as smoothness of the modal input, distribution of the input nodes over the surface, the value of various parameters associated with each method, and the location of output nodes; it is only through the experience of using the different methods that an analyst can be assured of obtaining good interpolation results. When performing interpolation on a surface for the first time, it is recommended that the user examine the interpolated output to insure the proper results are being obtained. The following is a discussion of each method.

4.4.1 MOTION POINT

The motion point interpolation method uses modal displacements defined at a single node point to determine the motion at any set of output points (see fig. 5). For example, in a vibration analysis a nacelle may be modeled as a rigid body attached to a wing. In such a case, the motion of the nacelle is defined by the modal displacement of its center of gravity. Using the center of gravity as the input node, motion point can be used to determine the required displacements at the various control points of the slender body used to aerodynamically model the nacelle.

Table 1. – Typical Interpolation Method Uses

Interpolation method	Source of modal data for a surface	Type of aerodynamic body surface represented
Motion point	Motion defined at a single node	Nacelle, fuselage, control surface
Motion axis	Motion defined on elastic axis	Wing, horizontal tail, vertical tail, fuselage, control surface
Surface spline	Finite element analysis	Wing horizontal tail, vertical tail, control surface
Beam spline	Finite element analysis	Wing, horizontal tail, vertical tail, control surface
Polynominal	No modal input	All aerodynamic bodies

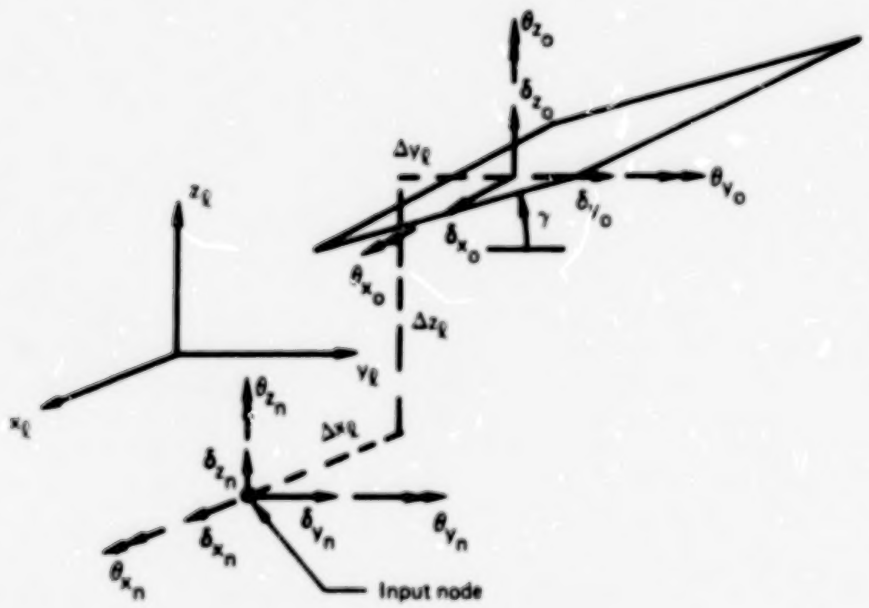

Figure 5.–Motion Point Interpolation

The determination of the output motion is made using the small angle rigid body displacement transformation, equation (7):

$$\begin{Bmatrix} \delta_x \\ \delta_y \\ \delta_z \\ \vartheta_x \\ \theta_y \\ \theta_z \end{Bmatrix}_o = \begin{bmatrix} 1 & 0 & 0 & 0 & \Delta z_\ell & -\Delta y_\ell \\ 0 & 1 & 0 & -\Delta z_\ell & 0 & \Delta x_\ell \\ 0 & 0 & 1 & \Delta y_\ell & -\Delta x_\ell & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} \delta_x \\ \delta_y \\ \delta_z \\ \theta_x \\ \theta_y \\ \theta_z \end{Bmatrix}_{\text{node}} \tag{7}$$

The quantities Δx_ℓ, Δy_ℓ, and Δz_ℓ represent the local axis system offsets between the input node and the output point. They are defined by:

$$\begin{aligned} \Delta x_\ell &= x_{\ell_o} - x_{\ell_n} \\ \Delta y_\ell &= y_{\ell_o} - y_{\ell_n} \\ \Delta z_\ell &= z_{\ell_o} - z_{\ell_n} \end{aligned} \tag{8}$$

The capability exists to orient the final motion to a surface that makes a dihedral angle, γ, with respect to the local x_ℓ, y_ℓ plane, equation (9):

$$\begin{aligned} \delta_z &= \delta_{z_o} (\cos\gamma) - \delta_{y_o} (\sin\gamma) \\ d\delta_z/dx &= -(\theta_{y_o} \cos\gamma + \theta_{z_o} \sin\gamma) \\ d\delta_z/dy &= \theta_{x_o} \end{aligned} \tag{9}$$

Though input motion for motion point may consist of all six displacements, when used with the DYLOFLEX system only three displacements, δ_z, θ_x and θ_y, should be used. This restriction is a result of the way other DYLOFLEX programs use the interpolated results. For bodies that experience both vertical and lateral motion (such as nacelles), this restriction will require the formation of two interpolation arrays; one with its local z-axis lying in the direction of vertical displacement and the second with its local z-axis lying in the direction of the lateral displacement.

4.4.2 MOTION AXIS

The motion axis interpolation method is most commonly used to determine the displacements and slopes on lifting surfaces and slender body axes when the mode shapes are generated from a lumped mass-beam model. In such cases, the modal displacements are associated with nodes that lie in a plane and define an axis composed

of straight line segments (e.g., the elastic axis of a high-aspect-ratio wing, or the hinge line of an aerodynamic control surface). The motion axis itself is defined by a series of definition points that have a reference line associated with them. The orientation of the reference lines is established by the user, and does not have to lie perpendicular to the motion axis (see fig. 6). The functions of the reference lines are to establish the interpolation regions over the surface and to determine attachment locations of the desired output points on the motion axis.

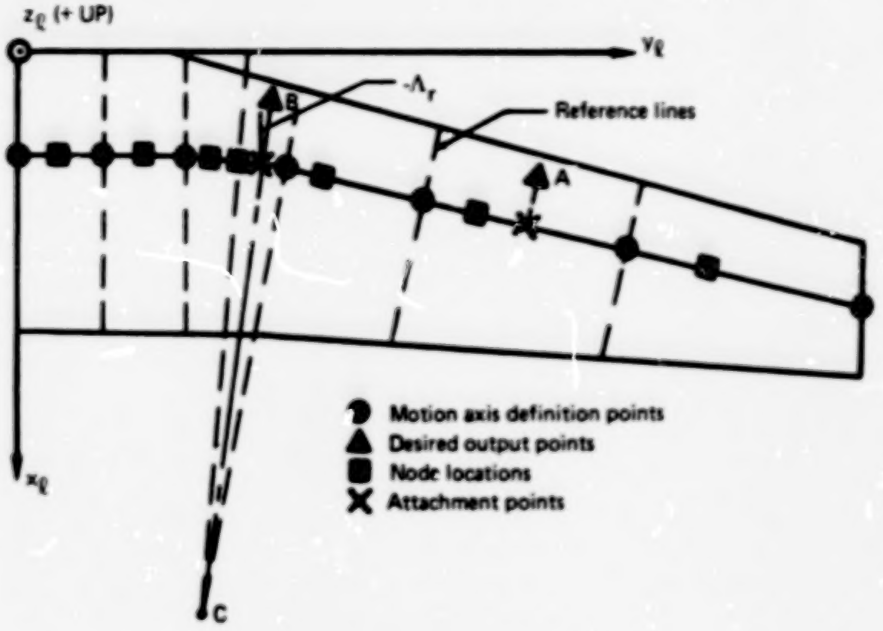

Figure 6.–Motion Axis Interpolation

Within each interpolation region, the motion axis is described by a cubic spline (eq. (10)); which is generated from the x-y coordinates of the motion axis definition points:

$$x = C_0+C_1y+C_2y^2+C_3y^3 \qquad y_i<y<y_{i+1} \tag{10}$$

where:

y_i, y_{i+1} = Inboard and outboard y locations of the ith interpolation region

C_0, C_1, C_2, C_3 = Cubic coefficients for the ith region

With the motion axis represented in this manner, the first and second derivatives will be continuous while maintaining a minimum of curvature over the interval (x_i, y_i) to (x_{i+1}, y_{i+1}). It is important to note that in modeling an elastic axis that consists of straight line segments, care must be taken in choosing the proper location and number of motion axis definition points. Definition points should be placed as close to the axis

breakpoints as possible, and a sufficient number of points should be included in between breakpoints to keep the amount of curvature introduced by the cubic function to a minimum.

The closeness of the definition point spacings is a function of the associated reference line orientations. In order to obtain best results, it is advisable to have two adjacent reference lines intersect off the surface of interest (see point C of fig. 6). Thus, to meet this guideline, the spanwise spacing of motion axis definition points is a function of the relative difference between the respective reference line orientations and the size of the surface of interest.

The motion axis method uses only three of the six possible nodal displacements, vertical translation (δ_z) and the two rotations (θ_x and θ_y). The rotations may be oriented parallel and perpendicular to either the freestream or the motion axis. Again, when used for bodies that experience both vertical and lateral motion, two separate SA arrays must be formed; one with its local z axis lying in the vertical displacement direction and the second with its local z axis lying in the lateral displacement direction.

The motion at a desired output point is found by first determining into which region the output point falls. Use is then made of the orientations of the reference lines defining the region to determine the point of attachment of the output point on the motion axis. If the reference lines defining the region are parallel (as is the case with point A, fig. 6), then an attachment line is drawn from the output point to the motion axis with the same orientation as the two reference lines. If the reference lines are not parallel (as with point B, fig. 6), the determination of the attachment point becomes more involved. First, the intersection of the two reference lines is determined (point C of fig. 6). This point is known as the segment mapping point. Next a line is drawn from the mapping point to the output location. This line becomes the attachment line of the output point. The intersection of this attachment line with the motion axis defines the point of attachment of the output point. This point is known as the output point's associated reference point. Displacements at the reference point are then determined by using cubic spline functions in arc length, defined over each interpolation region, to interpolate from the nodal input points to the reference point.

Motions at the reference point are then transformed to the output locations along the rigid attachment link. The transform equations are:

$$\delta_{z_O} = \delta_{z_r} + [\cos(\Lambda_r) * \theta_{y_r} - \sin(\Lambda_r) * \theta_{x_r}]\,\Delta r \tag{11}$$

$$d\delta_{z_O}/dx = -\theta_{y_r}$$

$$d\delta_{z_O}/dy = \theta_{x_r}$$

where:

$\delta_{z_r}, \theta_{x_r}, \theta_{y_r}$	=	Vertical and rotational displacements at the reference point
$\delta_{z_o}, d\delta_{z_o}/dx,$ $d\delta_{z_o}/dy$	=	Vertical displacements and slopes at output locations
Λ_r	=	Orientation angle of the attachment line
Δr	=	Distance along the attachment line from the attachment point to the output point (positive for output point forward of motion axis)

4.4.3 BEAM SPLINE

The beam spline interpolation method is an extension of the motion axis method. This method is ordinarily used to determine displacements and slopes on lifting surfaces using modal data determined by a finite element analysis. In the beam spline technique, motion is defined along two or more beams that lie in the x-y plane of the surface. This motion consists of translations normal to the surface (δ_z) and rotations (θ_x and θ_y) that must be defined parallel and perpendicular to the freestream. The relationship of the beams with respect to each other may vary from parallel to intersecting, with the only restriction being that any streamwise interpolation must be performed over a minimum of two beams (see fig. 7).

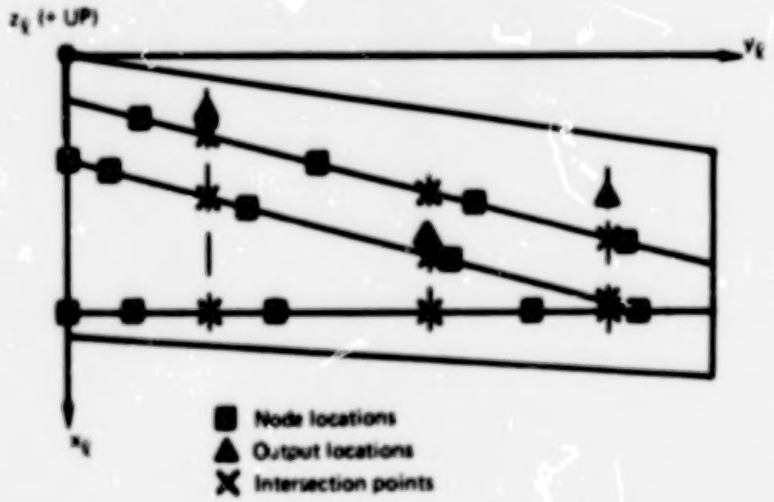

Figure 7.–Beam Spline Interpolation

Cubic spline functions of the form used in the motion axis method are determined for each beam, using the nodal locations assigned to each beam. These functions are combined with the nodal motions to generate a set of cubic functions in arc length (one for each beam) that are utilized to interpolate for motion at intersection points on the beams. The intersection points are determined by a streamwise cut made at the output point locations. The interpolated motion at the intersection points along any one streamwise cut form the set of data needed to generate a cubic function for each streamwise cut. The motion at the output points are then determined using the final set of streamwise cubic functions.

In some instances, beams may not extend the full span of the interpolation surface (see fig. 8). The user can extrapolate the input data of the shortened beams in the outboard and/or inboard direction. It is stated previously that to form the streamwise cubic functions used to interpolate to the desired output nodes, a minimum of two intersection points are required. This extrapolation capability allows the formation of the streamwise cubic function at locations on the surface where only one beam may be present. As is the case with all extrapolation processes, the results of the extrapolation should be examined by the user to insure their validity.

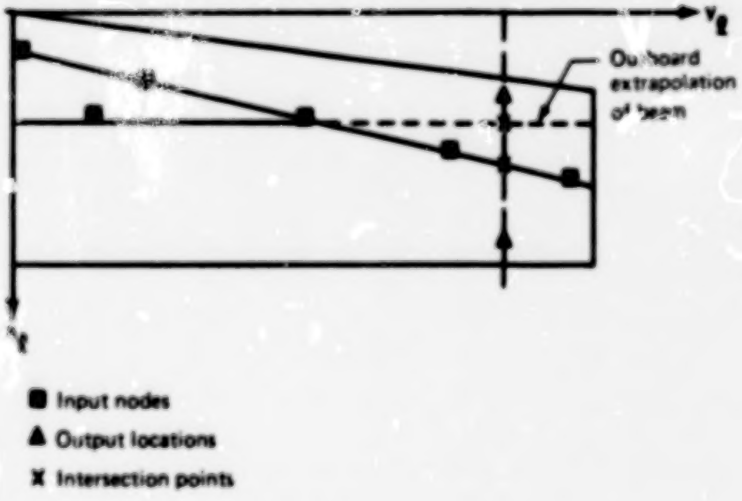

Figure 8. – Beam Spline Extrapolation

4.4.4 SURFACE SPLINE

The most general form of interpolation is the surface spline technique. This method uses the vertical deflections, δ_z, which are defined on a surface in a finite element analysis to develop a set of interpolation coefficients. The coefficients are determined by using

the solution to the differential equation of a circular isotropic plate of infinite radius subjected to point loads and pinned at the edges. The resulting expression for the deflection at any point is:

$$\delta_z(x,y) = \sum_{i=1}^{N} [\alpha_i r_i^2 \ln(r_i^2)] + \alpha_{N+1} + \alpha_{N+2}x + \alpha_{N+3}y \qquad (12)$$

where:

r_i^2 = $(x - x_i)^2 + (y - y_i)^2$

N = Number of nodes on the surface

$\alpha_i, \alpha_{N+1}, \alpha_{N+2}, \alpha_{N+3}$ = Interpolation coefficients

The interpolation coefficients are solved for, by using equation (12) to generate a set of N equations:

$$\delta_z(x_i,y_i) = \sum_{j=1}^{N} [\alpha_j r_{ij}^2 \ln(r_{ij}^2)] + \alpha_{N+1} + \alpha_{N+2}x_i + \alpha_{N+3}y_i \qquad (13)$$

$i = 1,N$

$r_{ij}^2 = (x_i - x_j)^2 + (y_i - y_j)^2$

along with the three additional equations:

$$\sum_{i=1}^{N} \alpha_i = \sum_{i=1}^{N} \alpha_i x_i = \sum_{i=1}^{N} \alpha_i y_i = 0 \qquad (14)$$

which are derived from the plate boundary conditions. Equation (12) can be altered to include a smoothing factor, Sk_i that are used to affect the interpolated results:

$$\delta_z(x,y) = \sum_{i=1}^{N} [\alpha_i (r_i^2 \ln(r_i^2) + Sk_i)] + \alpha_{N+1} + \alpha_{N+2}x + \alpha_{N+3}y \qquad (15)$$

A different smoothing factor may be applied to each node or one factor may be used for all the nodes on the surface. The choice of smoothing factors is completely arbitrary and is usually made after the analyst has examined the results of interpolation without employing any factors. It is important to note that if smoothing factors are used, interpolating back to the data input points will not give the exact input deflections because the effect of the smoothing factors is to relieve this constraint.

The surface slopes are given by:

$$d\delta_z(x,y)/dx = 2\sum_{j=1}^{N} a_j [1 + \ln(r_j^2)](x - x_j) + a_{N+2}$$

and:

$$d\delta_z(x,y)/dy = 2\sum_{j=1}^{N} a_j [1 + \ln(r_j^2)] (y - y_j) + a_{N+3} \quad (16)$$

4.4.5 POLYNOMIAL

The last type of interpolation is the polynomial method. This method requires no modal input and can be used to define displacements on any type of aerodynamic surface. The user simply defines the order and the coefficients of a polynomial that describes the surface vertical deflection:

$$\delta_z(x,y) = \sum_{i=0}^{n} \sum_{j=0}^{n-i} C_{ij} x^i y^j$$

and:

$$d\delta_z/dx = \sum_{i=1}^{n} \sum_{j=0}^{n-i} i C_{ij} x^{i-1} y^j$$

$$d\delta_z/dy = \sum_{i=0}^{n} \sum_{j=1}^{n-i} j C_{ij} x^i y^{j-1} \quad (17)$$

4.5 PARENT SURFACE MODES

In defining the modal input for a surface, the capability exists to use the SA array of a previously defined surface to calculate the motion of another surface at a common point of attachment. The surface whose SA array is used is called the parent surface. The surface that uses the parent surface SA array is called the dependent surface. This option is most commonly used with the control surface rotation option described in the next section. If a control surface rotation is to be added to the basic set of modal freedoms, this option can be exercised to define the modal displacements along the control surface hinge line for the basic set of freedoms. In this way, the analyst may account for a moving control surface without having to rerun the basic vibration analysis. This option may also be used to define the motion at the attachment point of a rigid surface to a flexible surface. Then interpolating from the attachment point using the motion point method, the displacements over the rigid surface can be defined.

Nodal locations on the dependent surface are used as output points with the parent surface SA arrays to generate modal displacements at the dependent surface's nodal points. The surface vertical deflections and slopes obtained from the parent surface SA array then become the input motions for the dependent surface. Thus, the dependent surface input motions are given by:

$$\begin{aligned} \delta_{z_d} &= \delta_{z_p} \\ \theta_{x_d} &= d\delta_{z_p}/dy \\ \theta_{y_d} &= -d\delta_{z_p}/dx \end{aligned} \tag{18}$$

where the subscripts denote:

p = Parent surface

d = Dependent surface

The motions of the dependent surface can be used with any interpolation method that requires modal input. Proper use of the parent surface option requires that the parent and dependent surfaces have the same local axis system.

4.8 CONTROL SURFACE ROTATIONS

The interpolation program has the capability of adding a control surface rotational freedom to the basic set of modal freedoms. The user need only define the hinge line location and the amount of rotation about the hinge line (see fig. 9). The surface vertical deflection and slopes are calculated, assuming a rigid rotation of the control surface, and are given by the following equations:

(R is negative for points lying aft of the hinge line)

$$\begin{aligned} \delta_z &= R \cdot \theta_{HL} \\ \Lambda_{HL} &= \tan^{-1} \frac{x_{HL_O} - x_{HL_I}}{y_{HL_O} - y_{HL_I}} \\ \theta_y &= \theta_{HL} \cos \Lambda_{HL} \\ \theta_x &= \theta_{HL} \sin \Lambda_{HL} \end{aligned} \tag{19}$$

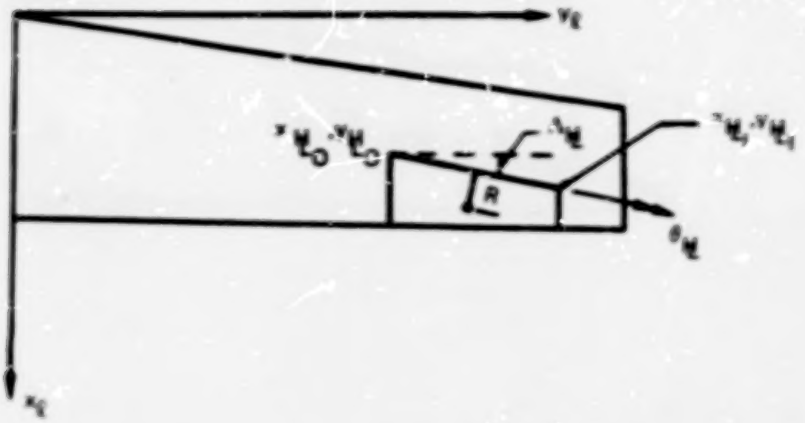

Figure 9. – Control Surface Rotation

4.7 AERODYNAMIC AXIS SHIFT

The formulation of the interpolation (SA) arrays is based on the local axis system that is defined with respect to the structural idealization. This local axis system will be denoted as the local structural axis system. The aerodynamic control points, however, are usually definded relative to a local axis system that is designated with respect to the aerodynamic idealization. This local axis will be called local aerodynamic axis system. It is often the case that the local structural axis system and its respective aerodynamic axis system become misaligned. Restrictions imposed by the aerodynamic idealization may place the local aerodynamic axis outboard or inboard, fore or aft, of the local structural axis. It is also a possibility that the simple calculation of the difference between the two origins will not yield the right amount of correction needed for proper spatial alignment (see fig. 10).

Therefore, the capability exists to adjust the coordinates of the aerodynamic control points in such a way as to bring them into the proper spatial alignment with the local structural axis. This adjustment is accomplished under the following two assumptions:

- The local aerodynamic axis x,y plane must lie in or parallel to the local structural axis x,y plane.
- The axes of the local aerodynamic system are parallel to their respective axes of the structural system.

Under these assumptions, the local structural axis system coordinates of the aerodynamic control points become:

$$\begin{Bmatrix} x \\ y \\ z \end{Bmatrix}_{\ell_s} = [R] \left(\left(\begin{Bmatrix} X \\ Y \\ Z \end{Bmatrix}_R - \begin{Bmatrix} XO_s \\ YO_s \\ ZO_s \end{Bmatrix}_R \right) - \begin{Bmatrix} \Delta x_{SH} \\ \Delta y_{SH} \\ 0 \end{Bmatrix}_{\ell_s} \right) \tag{20}$$

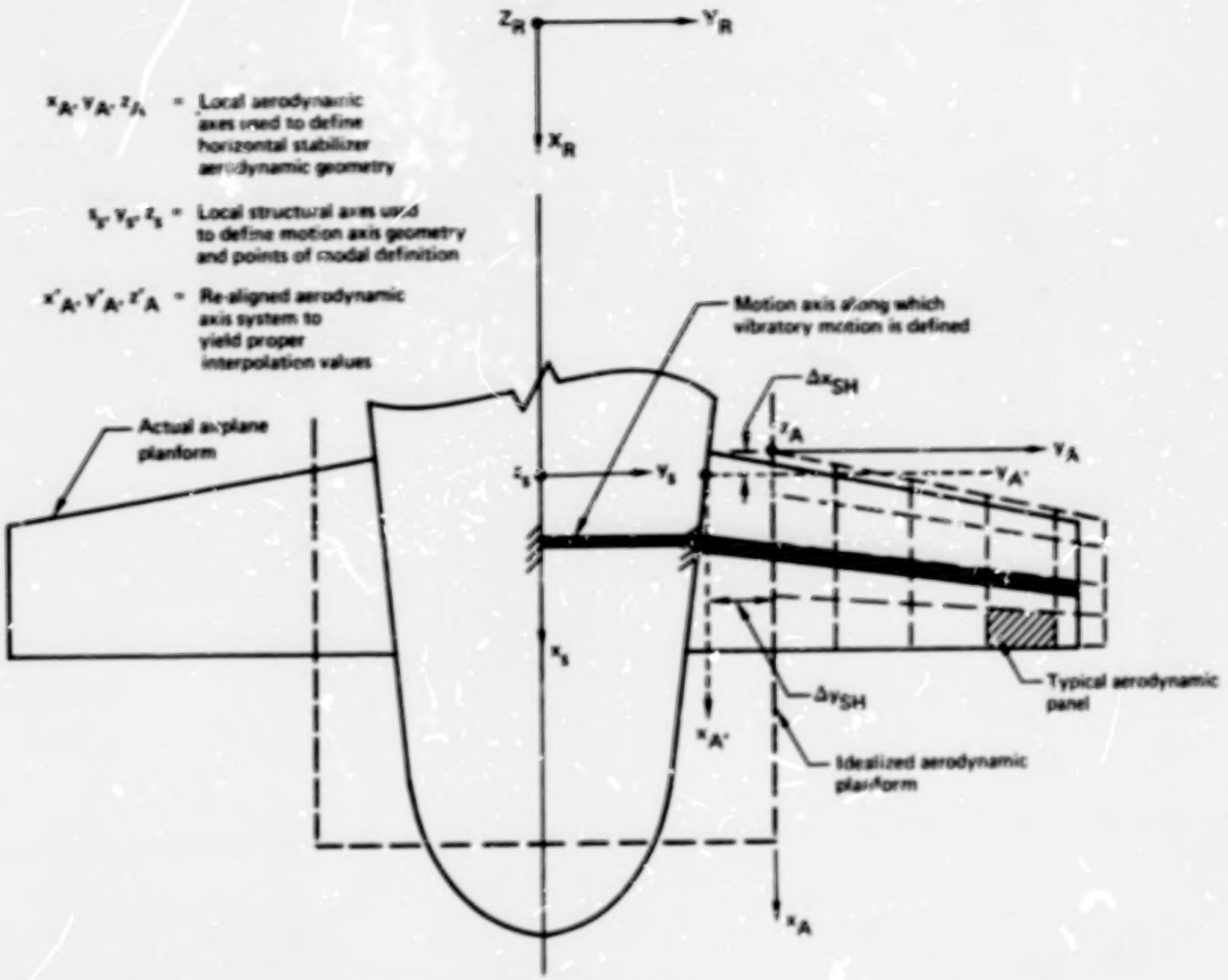

Figure 10. – Aerodynamic Axis Shift

where:

$\begin{Bmatrix} x \\ y \\ z \end{Bmatrix}_{\ell_s}$ = Coordinates of an aerodynamic control point defined in the local structural axis system

$[R]$ = Euler rotation matrix

$\begin{Bmatrix} X \\ Y \\ Z \end{Bmatrix}_R$ = Reference axis system coordinates of the aerodynamic control points

$\begin{Bmatrix} XO_s \\ YO_s \\ ZO_s \end{Bmatrix}_R$ = Reference axis system coordinates of the origin of the local structural axis

$\begin{Bmatrix} \Delta x_{SH} \\ \Delta y_{SH} \\ 0 \end{Bmatrix}_{\ell_s}$ = x and y shift values measured in the local structural axis and defined as the correction needed to place the local aerodynamic axis in the correct position with respect to the local structural axis

5.0 PROGRAM DESIGN AND STRUCTURE

5.1 FORMATION OF THE SA ARRAYS

SA array formation is carried out for each individual surface in six steps:

- Defining the surface orientation
- Inputting and sorting the nodal coordinates
- Defining scale factors
- Inputting and sorting the mode shapes
- Adding rigid surface freedoms if required
- Selecting the sorted freedoms and the type of modal interpolation method

The input required for each step may vary from surface to surface, depending upon the type of modal input and the interpolation method chosen. One problem variable that is constant for all surfaces is the total number of modal freedoms that are to be used to form the SA arrays, NTMODE (card set 4.0).

The number of modal freedoms used may be greater than or less than the number of modes input from the vibrational data. This gives the user the capability to increase or decrease the number of modes used in the structural analysis. By setting NTMODE greater than the number of input modes, additional freedoms can be added to the basic set of modes. In the same respect, making NTMODE smaller than the input freedoms allows the user to select the freedoms that are to be retained for the interpolation problem.

Surface Orientation

The orientation of the surface with respect to the reference axis system is established by inputting the reference axis system coordinates of the origin of the surface's local axis system and the Euler triad and rotation order required to rotate the reference axis system into the local axis system (card set 6.0). This data defines the coordinate transformation described in section 4.3. The transformation is needed only if nodal locations are input in reference axis system coordinates, or if surface orientation information is needed by other programs using data output by this program L215 (INTERP).

Nodal Input

Nodal data may be input via cards or magnetic file (card set 7.0), and the nodal coordinates may be defined in either the reference axis system or the surface's local axis system. If the coordinates are input in terms of the reference axis system, the transformation discussed in the previous paragraph is applied to obtain the local axis system locations of the nodes. Local axis system coordinates are needed because all interpolation is carried out in the local axis system.

Included as part of the nodal input data is a set of node orientation angles. The motion associated with each node may have an orientation that is different from that of the surface local axis system. For example, motion defined along an elastic axis might be oriented parallel and perpendicular to the axis and not to the freestream. In such a case, the surface rotation matrix would not describe the proper orientation of the nodal displacement with respect to the reference axis system. Since the modal data can be used in other programs, it is important to insure that the proper orientation is transmitted to these other programs. Therefore, the capability exists to input a set of Euler triads for each node.

These angles are not used within the interpolation program itself, but are merely present for passing information on to other programs. It is important to note that the Euler triad specified for each node will be applied in the same order as the surface's Euler triad specified on card 6.2. Also, the surface orientation angles given on card 6.2 will be used for any nodal angles that are not input. Thus, if the nodal motions of a surface only vary from the surface orientation by a sweep angle, the user need only input the node sweep angles. The other two Euler angles will be taken from the surface's Euler triad.

Once the node locations and orientations have been established, the only remaining task is the sorting of the input nodes. This is accomplished by the use of the nodal mapping option provided in card set 8.0. The sorting or mapping process is accomplished by the filling in of a null matrix. The row size of the null matrix may be less than or equal to the row size of the input matrix. In this way the number of nodes the analyst wishes to use in forming the SA arrays for the surface may be reduced. Mapping is essentially a re-ordering of the rows of the input coordinate data (see fig.11). If the mapping option is not exercised, the nodes will be used in the order in which they are read.

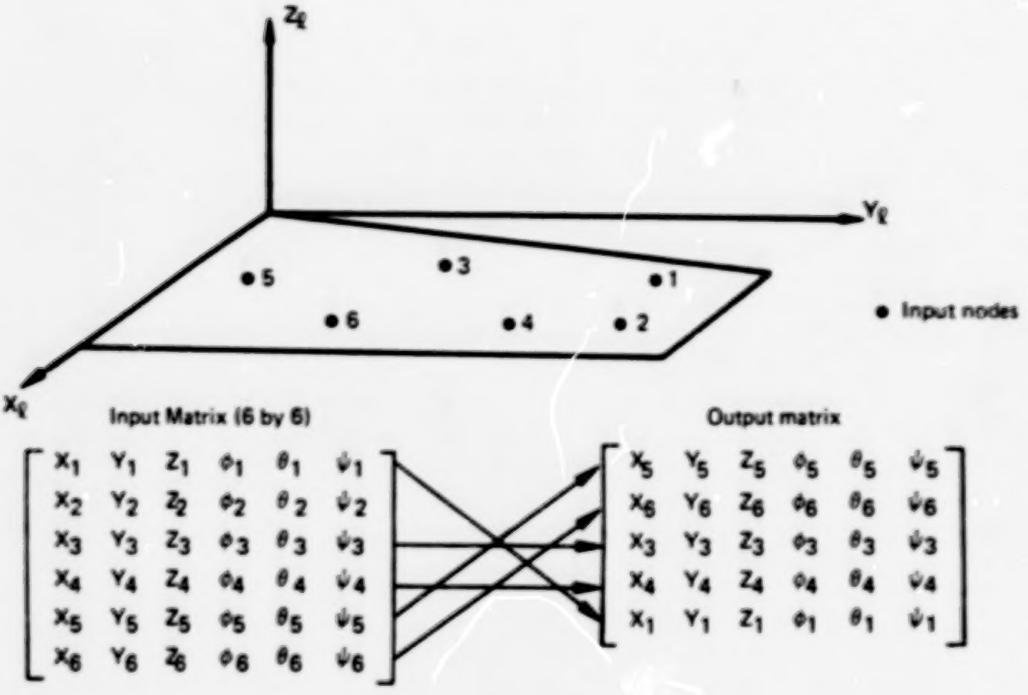

Figure 11. – Nodal Mapping

Scale Factors

The major function of the scale factors is to define the input motion which is used by the SA arrays in the sign convention shown in figure 2. Combining this capability with the modal sorting ability described next, the analyst can use vibration data defined in a different sign convention. The scale factors, though appearing before the sorting cards in the input data flow, are applied to the modal displacements after sorting has taken place. Thus, a scale factor on a δ_Z motion refers to the sorted δ_Z motion and not the δ_Z as defined in the vibration analysis. The scale factors only affect the mode shapes as they are used by the SA array, and are not applied to the sorted modes output on the magnetic file SATAP. Thus, one is able to perform a sign change on the input modes to make the motion compatible with the interpolation sign convention, yet leave the modes in their original sign convention to be used by other programs.

The dependent surface's scalars must have the same values as the parent surface's scalars to maintain the sign convention consistency between surfaces. Parent surface modal displacements, obtained from the parent surface SA array for use as input motion for a dependent surface, are returned to their original values before being used by the dependant surface. This is done to maintain a consistent sign convention between the sorted parent input modes and the sorted dependent input modes. Any modes appended to the parent surface must be defined in the original sign convention of the parent surface. Any rigid surface modes that are defined in the local axis system of the surface are redefined to be consistent with the other input modes of the surface before being appended to other modes.

Mode Shape Input

The modal displacement data for a surface can be input from two sources:

- Internal, using a previously defined SA array
- External, using mode shapes input via cards and/or magnetic file

The capability exists to use either one or both of these sources to compile the mode shape data needed for the surface SA arrays (card sets 10.0, 11.0, and 12.0).

The internal generation of mode shapes is done using the parent surface concept discussed in section 4.5. The user need only specify which previously defined SA array shall be used to generate the nodal displacements.

Mode shapes coming from external sources may be input in one or both of the following forms:

- Combined freedoms - One large matrix containing all the allowed displacements for each node (card set 11.0)
- Single freedoms - A set of up to six individual matricies with each matrix containing one type of motion for each node (card set 12.0)

Modal mapping capability exists with both forms and is used to place the modal data in single freedom format.

The modal mapping process is similar to the nodal mapping discussed earlier. Here, however, six null matrices are generated. Each matrix will eventually contain the desired mode shapes for the surface, and each will describe one type of motion for all the nodes. The process of filling the null matrices is carried out as directed by the user (see figs. 12 and 13). Sorting of mode shapes in this manner allows the user the freedom to reorder and redefine the input motion. It is this sorted motion (single freedom format) that is used as input for the creation of the SA array.

Rigid Surface Modes

Though modal freedoms may be merged by using both the combined freedom and single freedom input formats with a single surface, the rigid surface option allows the user a simple method of adding a rigid surface rotation mode to the basic set of input data (card set 12.0). This option, when used with the parent surface options, provides a convenient way of generating modal displacement for a control surface. Given the hinge line location and the amount of rotation about the hinge line, the interpolation program calculates the vertical displacements and slopes of the control surface node points. This motion is then appended to the basic set of modal data, which was generated using the point combined freedom input, the single freedom input, or the parent surface option.

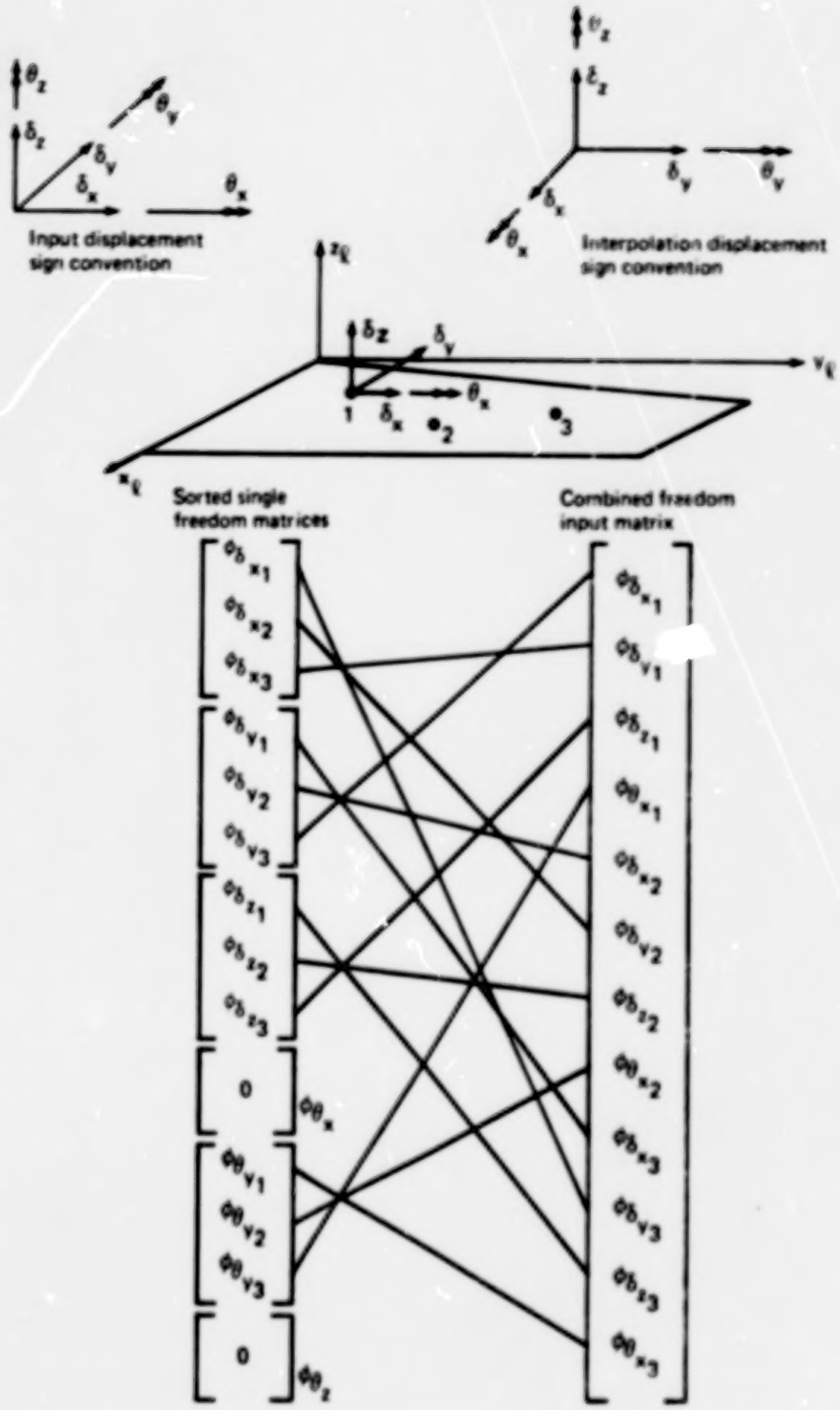
Input displacement sign convention
Interpolation displacement sign convention
Sorted single freedom matrices
Combined freedom input matrix

Figure 12. – Combined Freedom Mapping

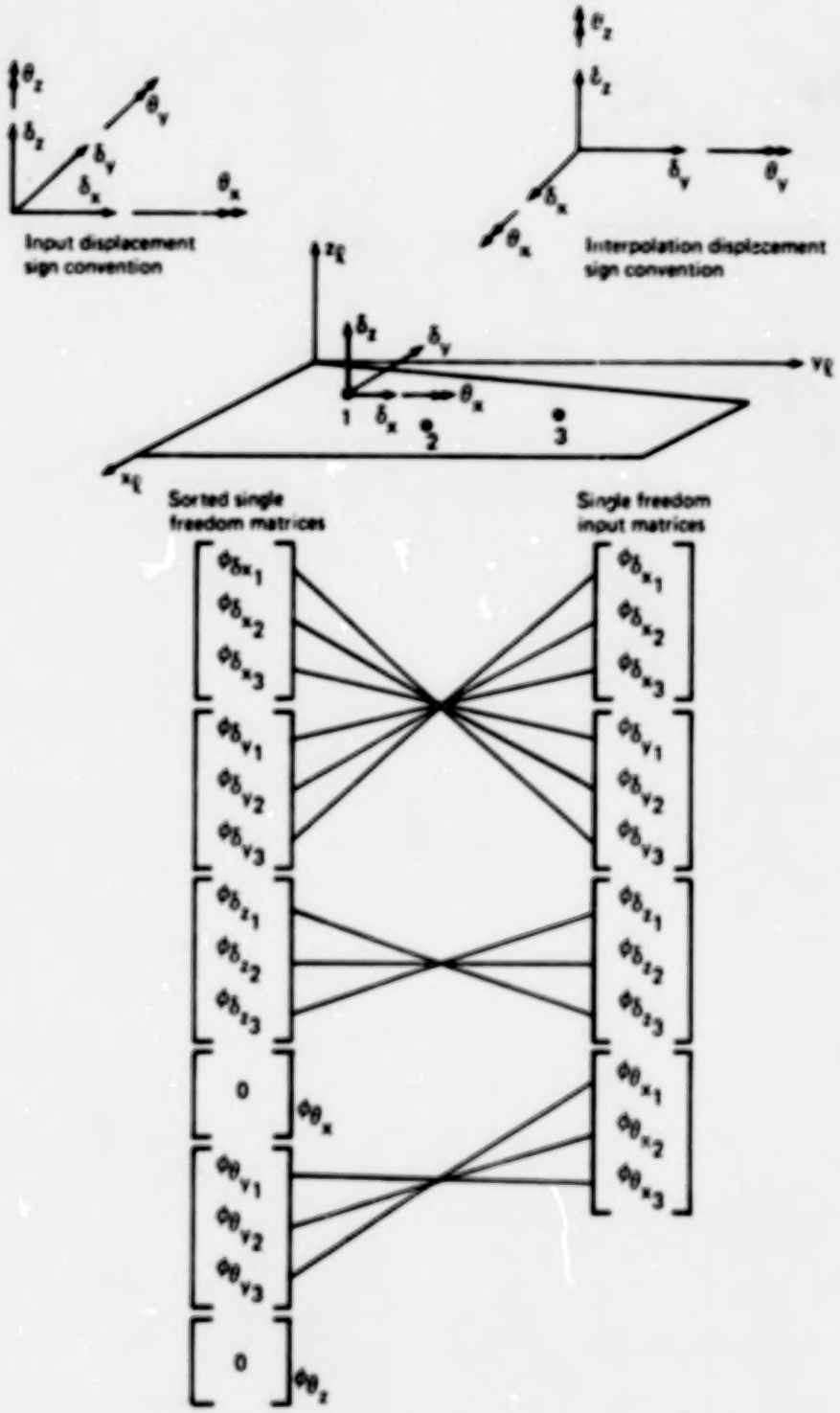
Input displacement sign convention
Interpolation displacement sign convention
Sorted single freedom matrices
Single freedom input matrices

Figure 13. – Single Freedom Mapping

Selection of Interpolation Method

The last step in the SA array formation process is the selection of the sorted freedoms to be used (card set 14.0) and the selection of the interpolation method (card sets 15.0 through 19.0). The freedoms that one uses will depend upon the type of interpolation chosen. Table 2 lists the interpolation methods and the permitted modal input associated with each method. It is the user's reponsibility to insure that the proper motion types are used with the selected method so that proper interpolation results are obtained. Multiple SA arrays (up to six) can be generated for any one surface by repeated use of card set 14.0 and the associated card set for the particular type of interpolation method.

Table 2. – Displacement Inputs, Need for the Different Interpolation Methods

Interpolation Method	No. of input Displacements	Comments
Motion point	1 to 6	Though all six modal displacements may be input for this method, DYLOFLEX users should only input the three displacements of δ_Z, θ_X and θ_Y.
Motion axis	3	The three displacement δ_Z, θ_X and θ_Y may be defined relative to the freestream or to the local motion axis.
Beam spline	1 to 3	There must be one translation, δ_Z. The θ_Y rotation is optional and is not needed for the $d\delta_Z/dx$ derivative calculation. θ_X displacement is also optional, but is required if the $d\delta_Z/dy$ derivative is desired.
Surface spline	1	The local δ_Z displacement is the only input required
Polynominal	0	No modal data required

5.2 DETERMINATION OF INTERPOLATED MOTION

The second phase of the interpolation program deals with the determination of local vertical translations and freestream slopes at specified output locations. This phase of the program may be executed by itself using SA arrays generated by a previous run, or it may be executed in conjunction with the first phase of the program as part of the same run. Since the downstream programs of the DYLOFLEX system only use the SA arrays from INTERP, the analyst has no means of judging the quality of the interpolation without executing some of the downstream programs. Thus the primary purpose of this phase is to provide the user with an easy means of examining the quality of the interpolation arrays that have been defined in the first phase of INTERP

The determination of interpolated motion introduces another local axis system called the local aerodynamic axis system. This system may have its origin at a different location with respect to the local structural axis which was used to develop the SA arrays, but it is required that the Euler triad used to describe the orientation of the local structural axes must also apply to the local aerodynamic axes. The location of the local aerodynamic axis system is defined by inputting the reference axis system coordinates of the origin of the local aerodynamic axis system (card set 24.0). The capability exists to shift the aerodynamic axis system with respect to the local structural axes. Card set 24.0 contains the variables XSH and YSH. These variables are the amount of shift between the desired final aerodynamic axis location and the location of the aerodynamic axis used for input. The values are measured in the local structural axis system. Figure 14 illustrates the use of the shift capability.

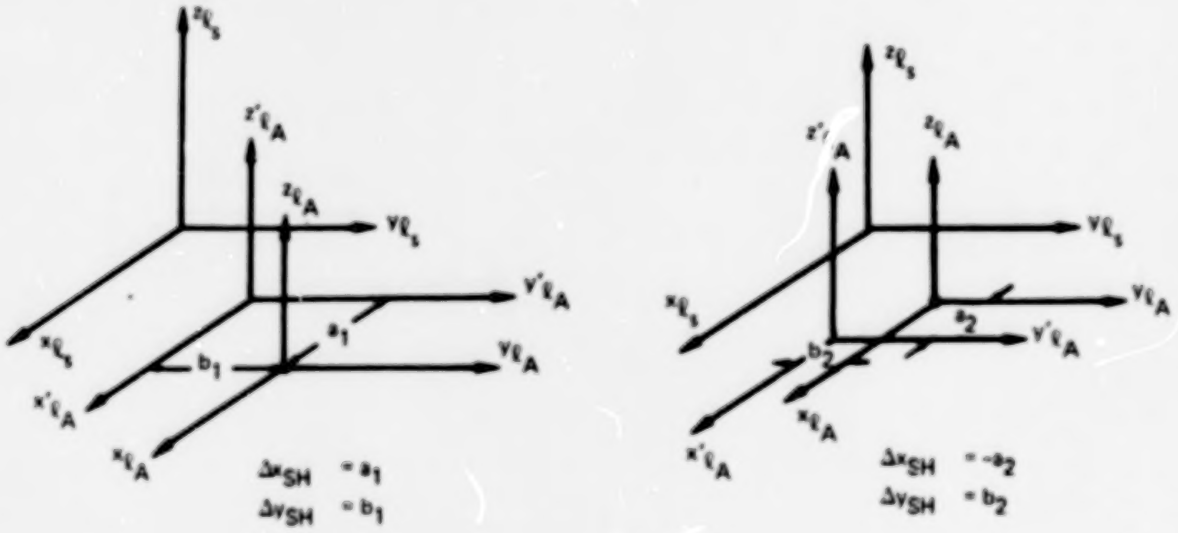

Figure 14.—Aerodynamic Axis Shifting

All output points that can be defined with the same local aerodynamic axis system may be considered as one set of data. The set grouping of output points can be independent of the surface grouping used in forming the SA arrays. Thus a set of output points may use more than one set of surface data. Take, for example, a wing having a moving control surface as shown in figure 15. The desired output points can be regarded as one set of data, yet two SA arrays may have been used to define the interpolation coefficients (see parent surface concept of section 4.5). The criterion for using SA arrays from different surface groupings for one set of output points is that the SA arrays must have been formed using the same structural axis system. For surfaces having more than one SA array, only the first SA array for the surface will be used. All others are ignored.

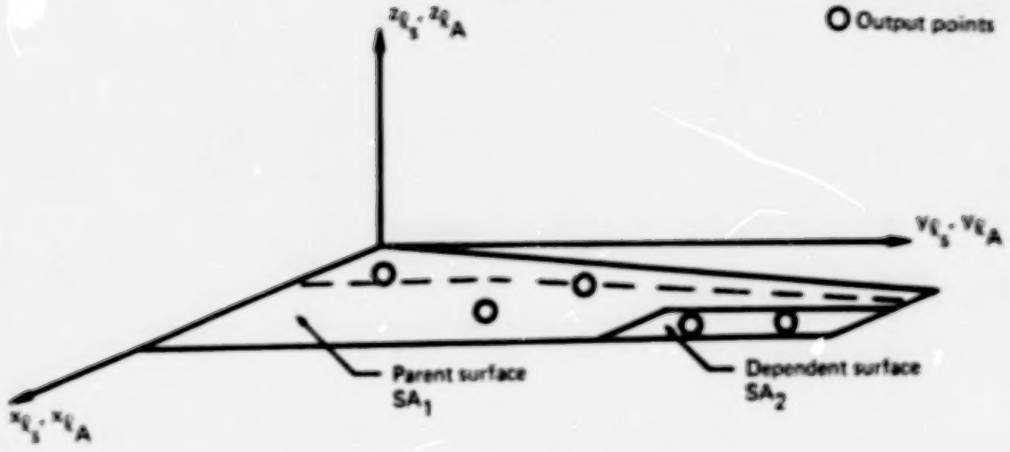

Figure 15. – Wing With Control Surface

The number of modes used for a set of output points may be less than or equal to the number used to form the SA arrays. If multiple SA arrays are used, the analyst can designate the number of modes to use, or elect the default option, in which case the total number of modes used will be taken from the first SA array encountered.

The user also has the option to rotate the interpolated motion to an orientation different from the surface orientation. The rotation is a simple dihedral rotation (fig. 16). This capability is useful when determining the normal motion on the panels of an interference body. The motion of the body, which is usually defined on the body's centerline, can be interpolated to the desired panel locations and then rotated into the normal of the panel. Each point in the output set may have a unique rotation, or one dihedral correction may be used for the entire set. This dihedral correction is given by equation (9), with the dihedral correction angle defined as

$$\gamma = \gamma_{\hat{n}} - \gamma_s$$

where:

γ_s = The local surface dihedral angle

$\gamma_{\hat{n}}$ = The unit normal orientation with respect to the z reference axis

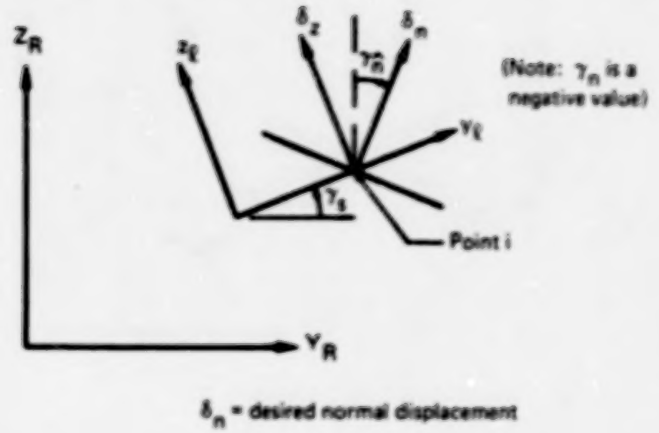

Figure 16. – Output Dihedral Correction

5.3 PROGRAM OVERLAY STRUCTURE

The L215 (INTERP) program is structured as an overlay system (see fig. 17), that carries out the execution in two phases. The (0,0) L215 and (1,0) INTERP overlays drive these two phases by calling into execution the secondary overlays requested by the user via card input data.

Phase I – Generate SA Arrays

Overlay(1,1) RDEDIT	Read and edit input data
Overlay (1,2) BEAM	Beam spline SA generator
Overlay (1,3) MOTA	Motion axis SA generator
Overlay (1,4) MOTP	Motion point SA generator
Overlay (1,5) POLY	Polynomial SA generator
Overlay (1,6) SURF	Surface spline SA generator
Overlay (1,7) RESULT	Save SA on SATAP

The (1,1) overlay RDEDIT reads and edits the card input data describing the formulation of SA arrays. Also, RDEDIT reads from user-specified files the nodal locations and modal displacements (translations and rotations). All of the edited input data is written onto the L215 (INTERP) scratch random file named SCRAND.

Next, the appropriate SA generation overlay is called. It reads the input data from SCRAND, generates the SA array, and writes it onto SCRAND.

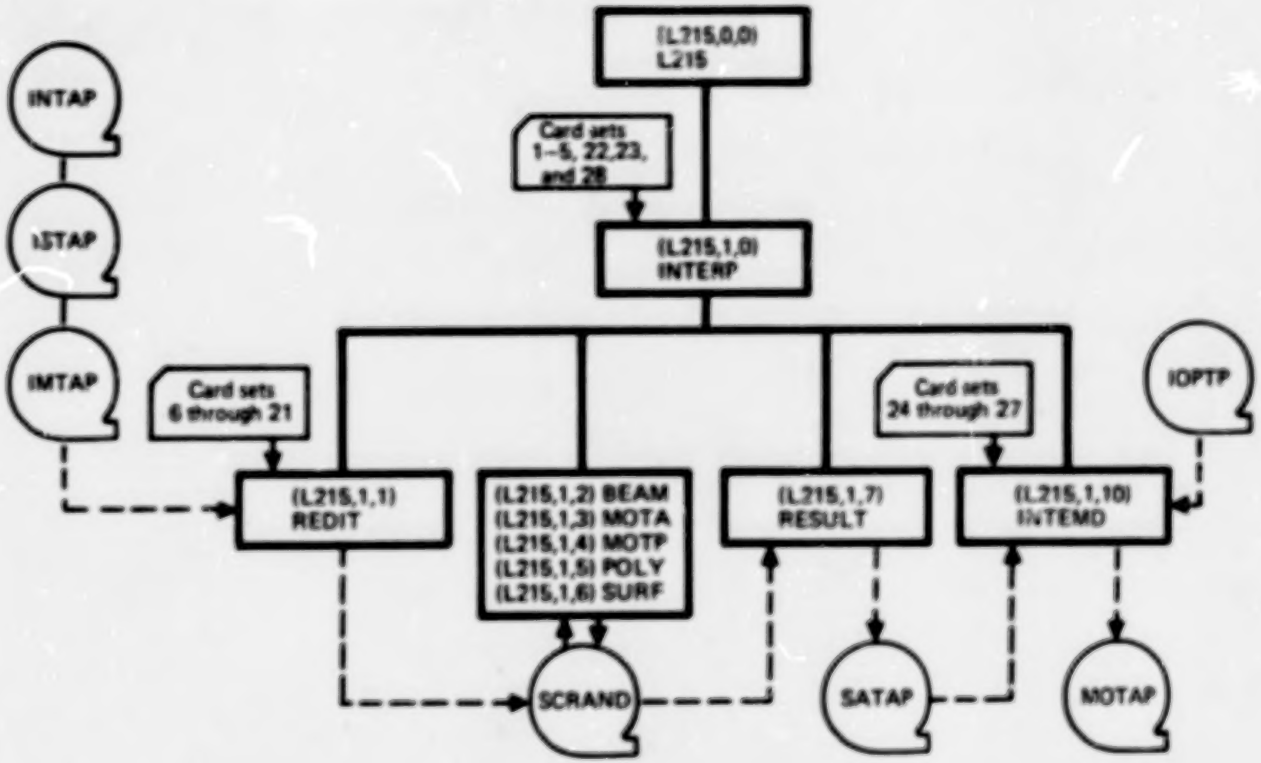

Figure 17. – Overlay Structure and Input/Output Files

Finally, the (1,7) overlay RESULT reads the single freedoms (ϕ'_s), nodal locations, and SA array from SCRAND and writes them onto the file SATAP.

Phase II - Determine Modes at Control Points

The (1,10) overlay INTEMD is called only when the user requests that mode shapes be found for specified control points. INTEMD reads the control point locations (from cards or a user-specified file) and the proper SA array from SATAP. It performs the interpolation using the SA array and writes the final output mode shapes on the file MOTAP.

6.0 COMPUTER PROGRAM USAGE

6.1 MACHINE REQUIREMENTS

The machine requirements for an execution of the modal interpolation program L215 are:

Card reader	To read control cards and card input data
Printer	To print the input data, standard output results, and diagnostic messages
Disk storage	All magnetic files not specifically defined as magnetic tapes are assumed to be disk files
Tape drive	For "permanent" storage of data on magnetic files, which are copied to and from magnetic tapes with control cards before and after program execution

6.2 OPERATING SYSTEM

L215 is written in FORTRAN for CDC 6000 or CYBER equipment. It may be compiled with either RUN or FTN compilers. It will run under the KRONOS 2.1 or NOS operating systems.

6.3 CONTROL CARDS

The following control cards are used to retrieve the absolute binary file from a master tape and execute the L215 program.

Job card
Account card

Prepare any input magnetic files

```
REQUEST(MASTER,VSN=66****,LB=KL,F=I)
REWIND(MASTER)
SKIPF (MASTER)
COPYBF(MASTER,L215)
RETURN(MASTER)
L215
```

Save any required output file

.
.
.

EXIT.
DMP(0, maximum field length)
  End-of-record
$INTErpolation initialization card

.
.
.

Required data cards

.
.
.

$QUIT terminating interpolation data
  End-of-file

6.4 RESOURCES ESTIMATES

Field Length

The field length required by L215 is dependent upon the problem size and the method of interpolation used. Core size must be requested for the largest module to be run. For a crude estimate, table 3 shows the field length required to run a set of sample problems. A more accurate field length estimate can be calculated by the equation below:

$$\text{Field Length} = \text{Maximum of} \left\{ \begin{array}{ll} \text{RDEDIT} & \\ \text{METHOD} & \\ \text{INTEMD} & \text{(Option for interpolated output)} \end{array} \right\}$$

RDEDIT has a value of:

$$\text{RDEDIT} = 75300_8 + \text{maximum of options used} \left\{ \begin{array}{l} \text{Normal modes} \\ \text{Rigid surface} \\ \text{Parent surface} \end{array} \right\}$$

where:

Normal modes = NNODES*NTMODE + NRPHI*NCPHI

Rigid surface = 6*(NNODES*NMODRS) + 12*NNODES + NNODES*NTMODE

Parent Surface = 3*(NNODES*NTMODE) + 12*NNODES + NSAE

Table 3.–Sample Problem Size and Resources Used

TEST CASE NUMBER	NUMBER OF NODES	NUMBER OF MODES	SIZE OF ROW	MODE SHAPE COLUMN	METHOD	FIELD LENGTH USED	CP SECONDS	RESIDENCE SECONDS
1A	4	3	4	3	BEAM SPLINE	75600$_8$	2	.04
1B	3	3	3	3	MOTION AXIS	75600$_8$	2	.12
1C	1	5	3	3	MOTION POINT	75600$_8$	2	.06
1D		3			POLYNOMIAL	75600$_8$	2	.06
1E	4	4	4	3	SURFACE SPLINE	75600$_8$	2	.12
3	34	11	102	8	MOTION AXIS	77600$_8$	12	.42
4	34	5	102	3	MOTION AXIS	76300$_8$	6	.20

and:

NNODES = Number of nodes

NTMODE = Number of modes

NRPHI = Number of rows in the input mode matrix

NCPHI = Number of columns in the input mode matrix

NMODRS = Number of rigid surface modes

NSAE = Number of element in the SA array (see below)

METHOD has a value that is a function of one of the five methods used: BEAM SPLINE, MOTIONAXIS, MOTIONPOINT, POLYNOMIAL, or SURFACE SPLINE. Values are given below:

BEAM SPLINE = 52600_8 + 3*(NNODES*NTMODE) + 6*NNODES + NSAE

MOTIONAXIS = 54000_8 + 3*(NNODES*NTMODE) + 6*NNODES + NSAE

MOTIONPOINT = 47500_8 + 6*(NNODES*NTMODE) + 3*NNODES + NSAE

POLYNOMIAL = 47000_8 + ((IORD+1)*(IORD+2))/2 + 30 + NSAE

SURFACE SPLINE = 51500_8 + (NNODES*NTMODE) + 3*NNODES + NSAE

where NSAE, the number of element in the SA array, is given below for each method:

Beam spline

NSAE = 17 + 6*NNODES + MAXO(8*MAXPTS,13*NBEAM) + ((INDC + 3)/2)*2*NNODES*NTMODE

For MAXO(A,B), use the larger of the two arguments.

Motion axis

NSAE = 9 + 10*NDEF + NNODES + 6*NNODES*NTMODE + 3*NTMODE

Motion point

NSAE = 10 + 6*NTMODE

Polynomial

NSAE = 8 = NTMODE*((IORD + 1)*(IORD + 2))/2

Surface spline

NSAE = MAXO (F1,F2)

with F1 = 17 + 2*NNODES + (NNODES + 3)*(NTMODE + 2) and
F2 = (NNODES + 3)**2 + (NNODES + 3)

where:

NNODES = Number of nodes

NTMODE = Number of modes

MAXPTS = Maximum number of points per beam

NBEAM = Number of beams

INDC = Indicator for freedoms
- = 0, TZ only
- = 1, TZ and RX
- = 2, TZ and RY
- = 3, TZ, RX, and RY

NDEF = Number of definition points

IORD = Order (degree) of polynomial

INTEMD, used only when interpolated output is requested, has a value as follows:

INTEMD = 71400_8 + 5*NOUTL + 3*(NOUTL*NTMODE) + NSAE

where NOUTL = number of output locations.

Note: The numbers computed from the given equations must be converted to an octal base number before adding to the program field length to find the required field length

Time Estimate

The central processor time required to run the program is dependent upon the problem size. The total time estimate would be the sum of the estimates for all surfaces. For a

single surface, IS, the time estimate in seconds should be:

$$CP_{IS} = 2 + (NMODES*NNODES)/100$$

where:

NMODES = Number of modes

NNODES = Number of nodes defining the surface

Printed Output

The printed output line limit is set to 40 000 lines at compilation time. This should be sufficient for any L215 program execution. The average line count is about 1200 lines.

6.5 INPUT DATA

The input data media used in the L215 program consist of cards and magnetic files. The card input data is described in section 6.5.1 and the magnetic file input data is described in section 6.5.3.

6.5.1 Card Input

All related blocks of card input data will be introduced, and in some cases terminated, with keywords located in the first ten characters of a card. In general, only the first five characters of the keyword will be checked to determine which block of data is to be read. The values of variables associated with the keyword will be read in fixed field formats either on the same card as the keyword or on the card(s) following. Unless otherwise noted, all variables appearing on optional cards will assume their default values if the card is omitted.

The special character "$" is used to denote program directive cards that begin and end L215 data ($INTE and $QUIT) and bracket data for the two phases of this program ($SURF-$END and $MODE-$END).

Note: All underlined capital characters contained in the keyword or variable fields of the card descriptions must be left justified and punched in the card columns designated in the columns field of the card set.

Figure 18 provides the overall picture of the card input data flow. Following figure 18 is a detailed description of each card set.

Card Set 1.0 - Modal Interpolation Card

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$INTErpola	A10	The $INTErpolation card indicates that the data following is for the modal interpolation program. This card must be the first card read by the modal interpolation program.

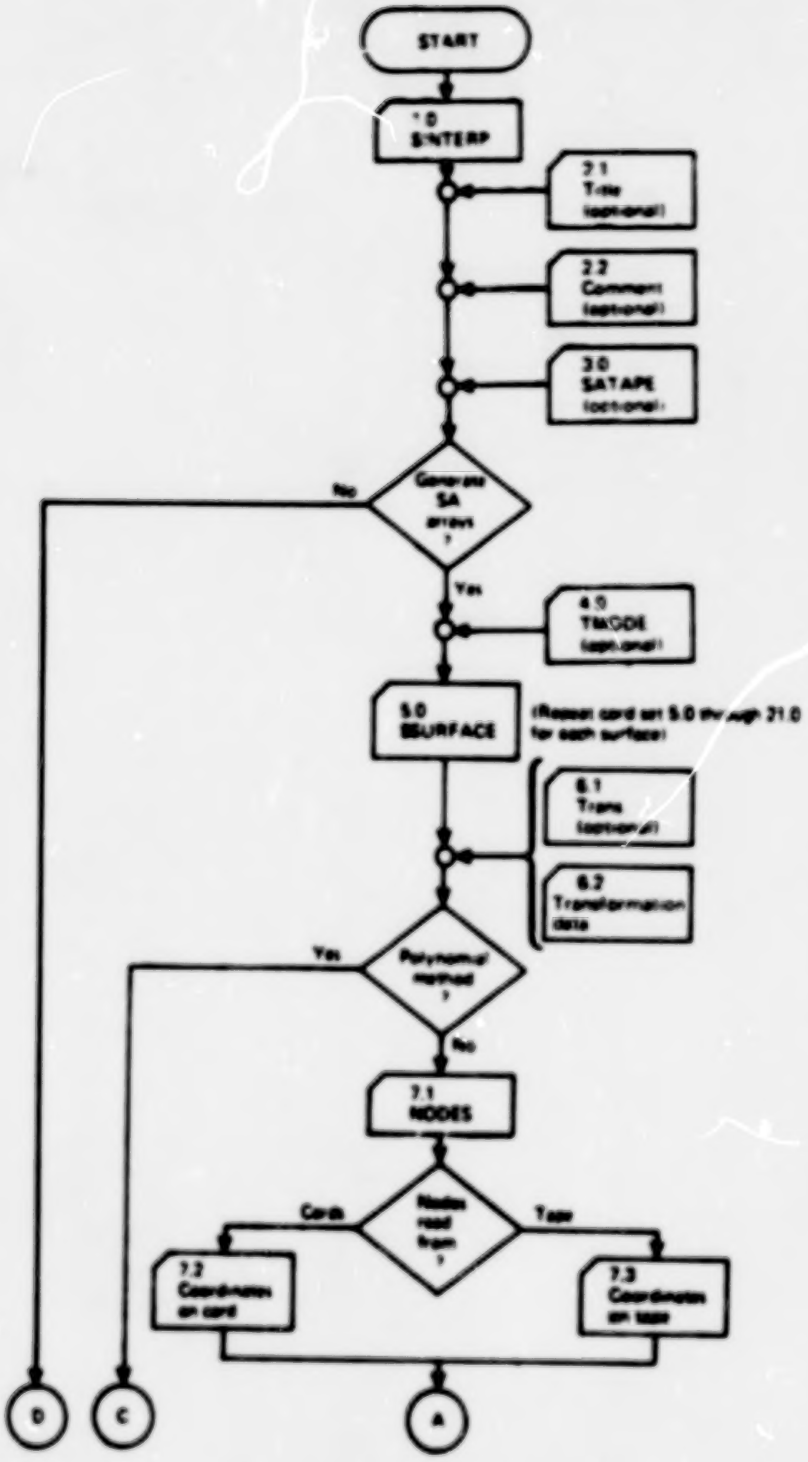

Figure 18. – Input Card Data Flow

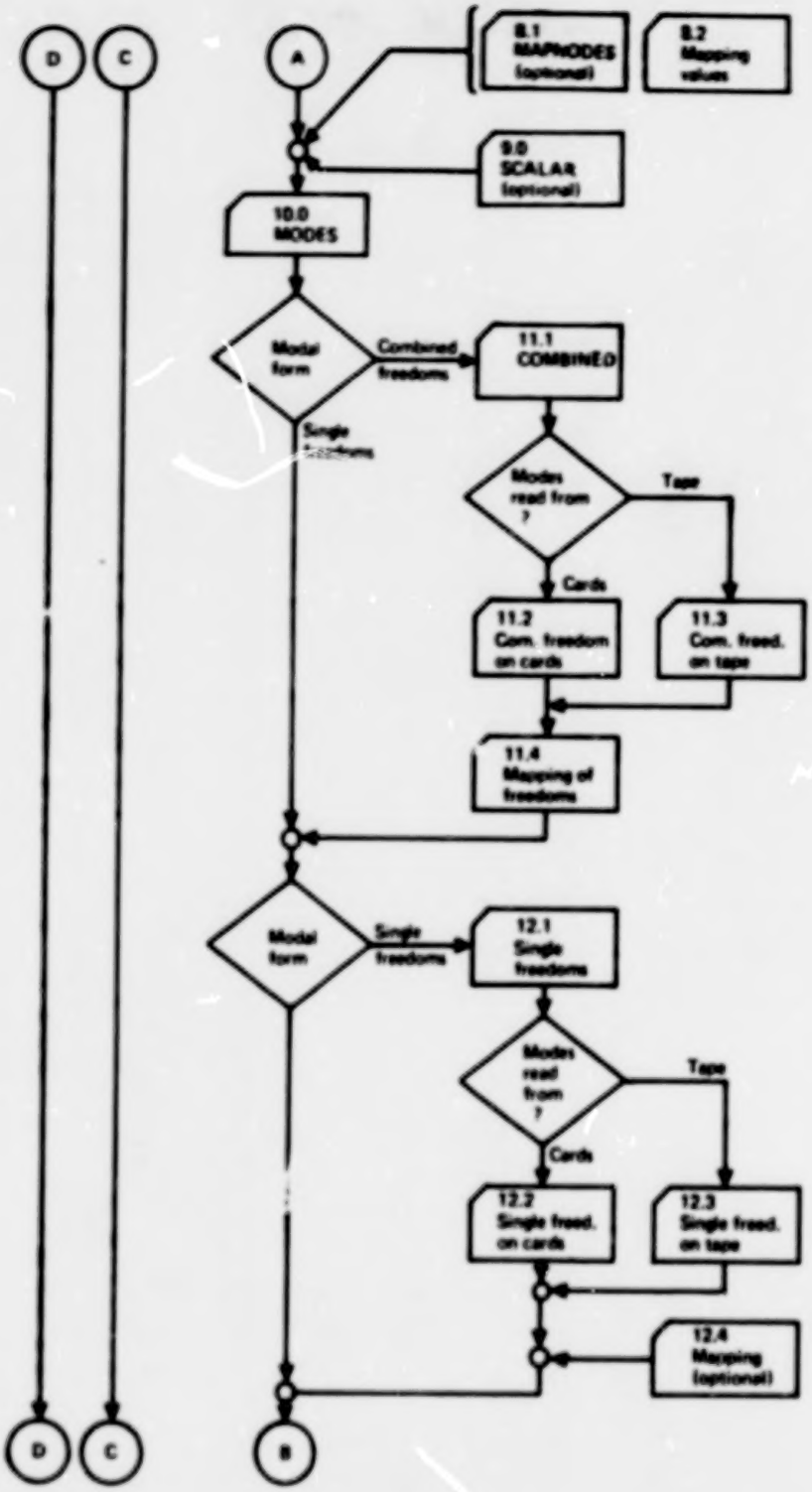

Figure 18. – (Continued)

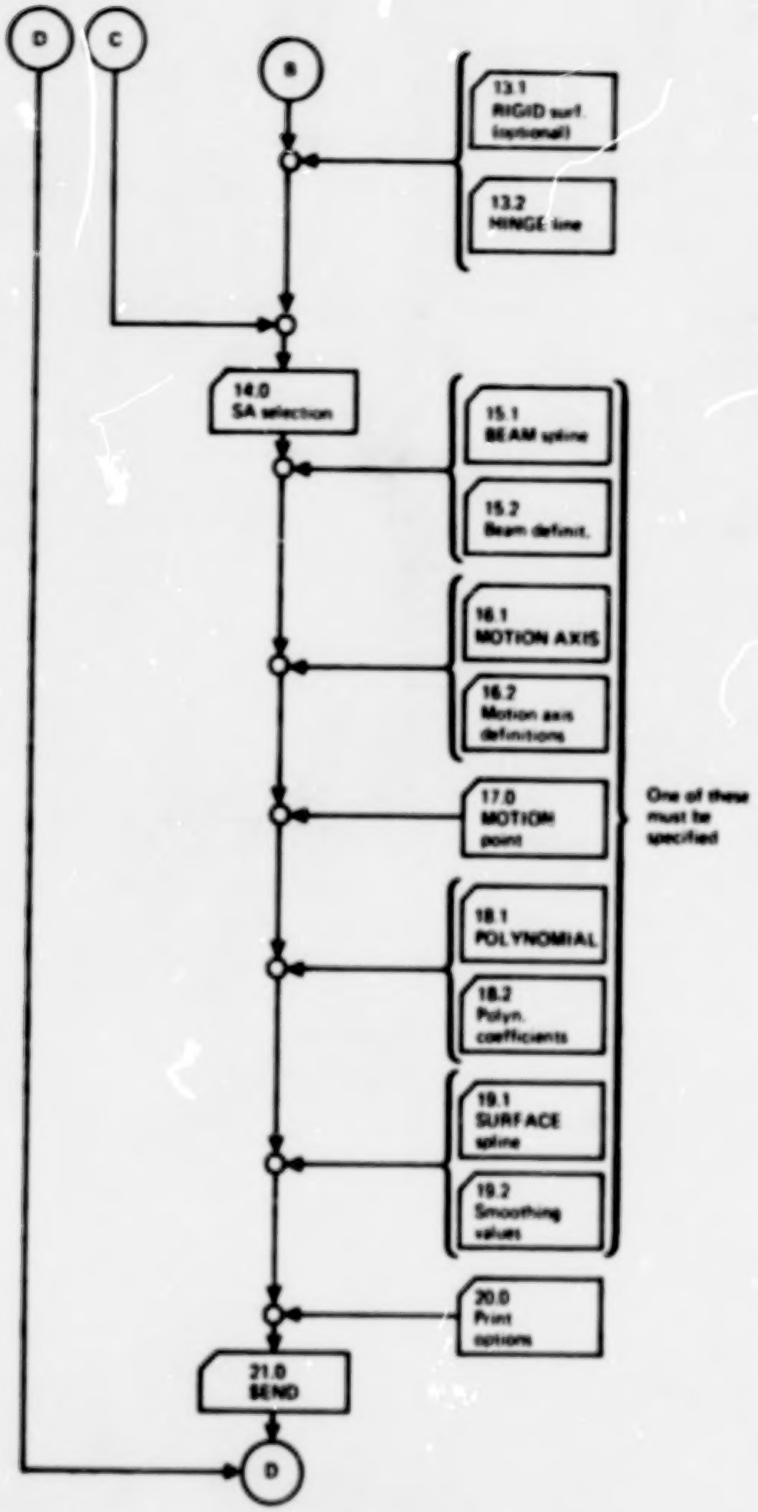

Figure 18. – (Continued)

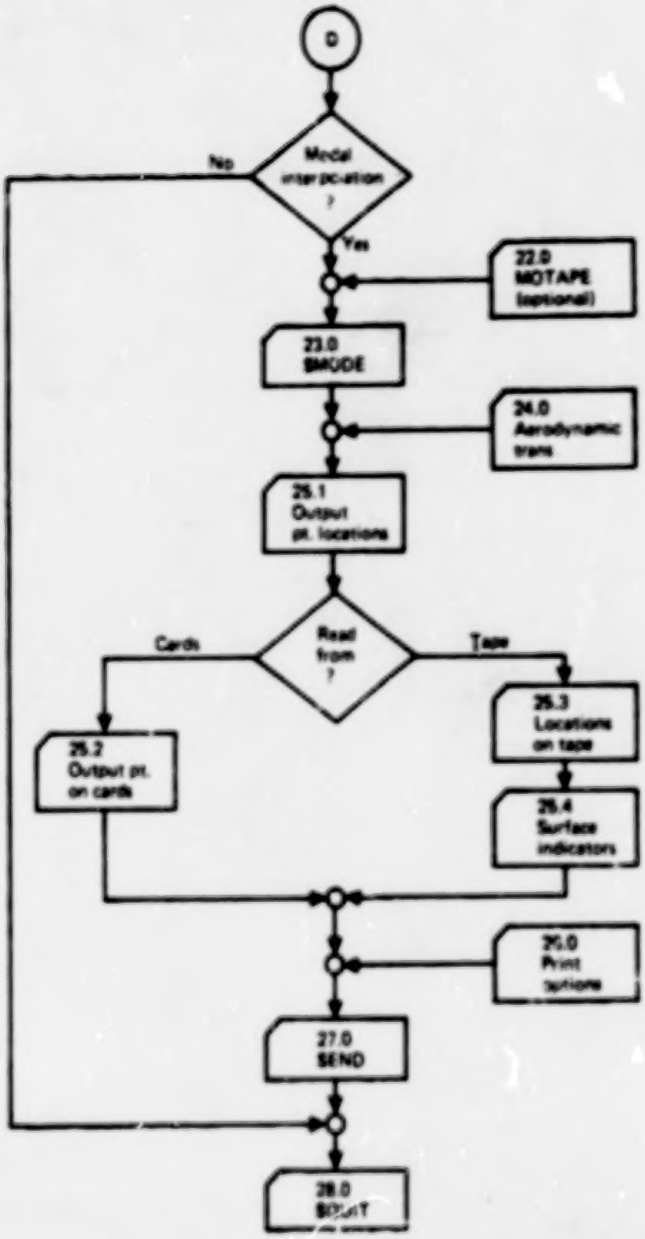

Figure 18. – (Concluded)

Card Set 2.0 - Data Case Labels

Card 2.1 - Job Title (Optional)

The title card may appear anywhere before a keyword. Up to four title cards appearing after the $INTErp card will be stored in core for page headings on printouts.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	TITLE	A10	Keyword for job title card.
11-80	Title	7A10	Job title which can provide description of the job.

Card 2.2 - Comment Card (Optional)

Comment cards may appear anywhere in the card input data stream except where data follows a keyword card.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	C	A2,8X	Keyword for comment card. NOTE: A blank in column 2 must follow the C in column 1.
11-80	Comment	7A10	Comments will appear in the printed output as they are read. They are not treated as data.

Card Set 3.0 - SA Array Tape Name (Optional)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	SATAPe	A10	Keyword indicating the SA array tape name.
11-20	ISATP	A7,3X	Name of the tape on which the SA arrays will be written, or on which they are already written. (Default = SATAP) NOTE: Input tape with SA arrays is needed when generating interpolated mode shapes for output points.

If SA arrays are already generated and only output mode shapes are required, go to card set 22-0.

Card Set 4.0 – Total Number of Modes (Optional)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	TMODE	A10	Keyword specifying the number of output modes.
11-15	NTMODE	I5	Total number of modes (columns) which will be used for in generating the SA arrays. (Default: NTMODE = 1)

Note: The maximum number of modes must be determined in conjunction with the number of nodes used on a surface NNODES (card 8.1) and the interpolation method chosen for the surface. The only size restriction is that the SA array for a surface cannot exceed 10,000 words. SA array size calculations are given in section 6.4.

Repeat card sets 5.0 through 21.0 for each surface.

Card Set 5.0 – Surface Definition

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	SURFace	A10	Keyword introducing the block of data that defines a surface.
11-15	ISURF	I5	The surface number. Also the actual file position of the SATAP where the results for this surface will be written. (no default)
16-20	blanks	5X	
21-30	ID	A10	Mnemonic identification of this surface*

***Used to aid in the identification of the surface (e.g. wing, vertical tail, fuselage, etc.)**

Card Set 6.0 - Surface Transformation Data (Optional)

If the surface's local axis system coincides with the reference axis system, then this card set may be omitted. The default values for all variables on card 6.2 are zero.

Card 6.1 - Transformation Data

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	TRANS	A10	Keyword indicating the transformation data for this surface follows, card 6.2.

Card 6.2 - Rotation Angles and Translation Data

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10 11-20 21-30	XR YR ZR	E10.0 E10.0 E10.0	Reference axis system coordinates of the origin of the surface's local axis system.
31-40 41-50 51-60	XRANG YRANG ZRANG	E10.0 E10.0 E10.0	Euler rotation angles which define the rotation of the reference axis system into the local axis system. (Degrees)
61-70	ORDER aaa	A10	Keyword indicating specification of Euler rotation sequence where aaa specifies sequence such as: XYZ, YXZ, ZYX, etc. (Default: ORDER XYZ)* NOTE: The two blanks after ORDER are part of keyword.

***See the sample problem input data listed in section 7.0.**

If POLYNOMIAL method selected (card set 18.0), skip to card set 14.0. If any of the other four methods are selected, continue with card set 7.0.

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Card Set 7.0 – Nodal Data

Card 7.1 – Definition of Nodal Coordinate Data

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	NODEs	A10	Keyword introducing nodal coordinate input data.
11-20	READ FROM	10X	Descriptive words (optional
21-30	{CARD / TAPE}	A10	Keywords indicating nodes input from CARD or TAPE
31-40	{LOCal / REFerence}	A10	Keywords indicating nodal coordinates being input are defined in LOCal axis system or REFerence axis system.
41-45	NNODEI	I5	Number of nodes being input (row size of node coordinate matrix) (Default: NNODEI = 1)
46-50	blanks	5X	
51-60	{ENGLISH / METRIC}	A10	Keyword indicating the nodal coordinates are defined in ENGLISH units or METRIC units. (Default: METRIC)

Card 7.2 – Nodal Data on Cards

Read this card if columns 21 through 30 contain keyword CARD on card 7.1. Repeat this card NNODEI times, one card for each node.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	XN_I	E10.0	The X, Y and Z coordinates of the Ith node.
11-20	YN_I	E10.0	I = 1, NNODEI
21-30	ZN_I	E10.0	
31-40	RXN_I	E10.0	X, Y and Z rotation angles which define the orientation
41-50	RYN_I	E10.0	of the node with respect to the reference axis system.
51-60	RZN_I	E10.0	(Degrees) NOTE: The order of rotation is that defined on card 6.2 If these variables are blank, rotation angles on card 6.2 will be used. The node rotation angles are written on output tape and are not used in the interpolation program.

Card 7.3 – Nodal Data on Tape

Read this card if columns 21 through 30 contain keyword TAPE on card 7.1.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	INTAP	A7,3X	The name of the tape containing the nodal coordinate input data. The tape name must begin with an alphabetic character and must contain no more than seven (7) characters. (no default)
11-15	INFP	I5	The logical file position number on INTAP where nodal coordinate data is found. (Default: INFP = 1)
16-20	INMP	I5	The matrix position number in INFP file where node coordinates are found. (Default: INMP = 1)
21-25	IROT	I5	Rotation matrix indicator. Rotation matrix contains the ϕ, θ, ψ orientation angles for each node. = 3, no rotation matrix read = 1, read rotation matrix after coordinate matrix

Card Set 8.0 – Input for Node Reordering (Optional)

Reordering may be used to change the order in which the nodes will be used in forming the SA array from the order in which they were used in calculating the modes shapes (e.g. change body node order from aft-to-nose to nose-to-aft or wing node order from tip-to-root to root-to-tip). Also, nodes may be eliminated with this option.

Card 8.1 – Mapping of Coordinates

If nodes are input in sorted form these cards are not needed.

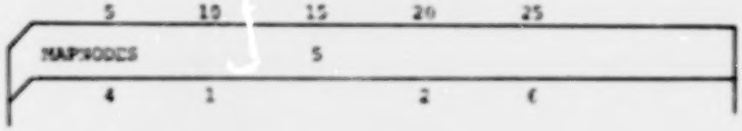
COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	MAPNEW	A10	Keyword indicating the reordering, selecting, or mapping of node coordinates.
11-15	NNODES	I5	Number of nodes to be retained. (Default: NNODES = NNODE1)

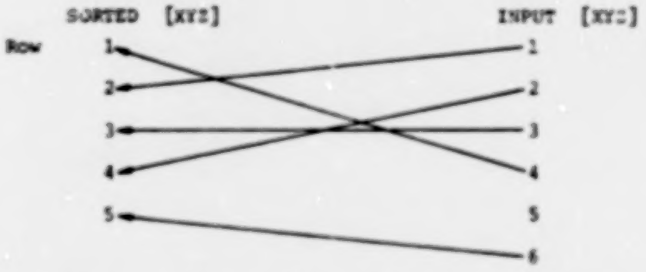
Card 8.2 - Mapping Values

Repeat this card (at 14 entries per card) until all NNODES nodes have been reordered.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-70	$IMAPNO_I$	14I5	The number of the row of the input node matrix which is placed in the Ith row of the sorted matrix. (Default: $IMAPNO_I = I$)

Example:





Card Set 9.0 - Scalars For Sorted Freedoms

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	SCALar	A10	Keyword indicating that scalars are to be used to multiply each single freedom.
11-20	SCALTX	6E10.0	Scalars to multiply the respective freedoms. (Default = 1.0)
21-30	SCALTY		
31-40	SCALTZ		
41-50	SCALRX		
51-60	SCALRY		
61-70	SCALRZ		

Note: This card is used to change the sign of the sorted freedoms that will be used to form the SA arrays. The sorted input data that is written on the SA array tape will not be changed. Dependent surface scalar values must be the same as parent surface scalar values.

Card Set 10.0 – Modal Input

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	MODES	A10	Keyword introducing the modal input.
11-20	FROM	A10	Optional keyword indicating that mode shapes are to be generated from a previous (parent) surface. If modal input is from external data, this field is left blank.
21-25	IISURF	I5	The surface number of the parent surface from which modal data will be generated. NOTE: IISURF must be less than ISURF found on the SSURFACE card for this surface. (Default: No parent surface)

Note: Card set 10.0 is followed by card sets 11.0, 12.0, and 13.0. The user has the capability of inputting modes in any combination of the following three forms:

1. **Card set 11.0 is the most general form. A single modes matrix contains all the local motions. It is sorted and grouped into single freedoms by the mapping cards.**
2. **Card set 12.0; each matrix is already in single freedom groupings and may be sorted by the mapping card.**
3. **Card set 13.0; the modes matrix is generated from the definition of a rigid surface.**

Card Set 11.0 - Modal Data in Combined Freedom Form (Optional)

Card 11.1 - Combined Freedom Input Definition

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	COMBined	A10	Keyword indicating modal data being input in combined freedoms form.
11-20	FROM	10X	Descriptive word (optional).
21-30	CARD / TAPE	A10	Keyword indicates modal data read from CARD or TAPE.
31-35	NROWCM	I5	Row size of combined modes.
36-40	NCOLCM	I5	Column size of combined modes.
41-45	ISICM	I5	Starting column of input modal matrix from which modes will be picked up.
46-50	ISOCM	I5	Starting column of output single freedom matrices into which modes will be sorted.
51-55	NMODCM	I5	Number of columns to use from the input modes starting at ISICM.

Note: NROWCM will usually be equal to NNODEI (card 7.1), but it is not requried to be the same. NCOLCM may be equal to, greater than, or less than NTMODE (card set 4.0). In this way, modal freedoms may be added or deleted.

Card 11.2 - Combined Freedoms From Cards

Read this card if columns 21 through 30 on card 11.1 contains the keyword CARD. Repeat this card NROWCM times.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-70	$COM_{I,J}$	7E10.3	Mode shapes read in by rows. Each row begins a new card. ($COM_{I,J}$, J = 1, NCOLCM) (I = 1,NROWCM)

Card 11.3 – Combined Freedoms on Tape

Read this card if columns 21 through 30 on card 11.1 contain the keyword TAPE.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	IMTAP	A7,3X	Name of tape containing the combined freedom modal matrix. The tape name must begin with an alphabetic character and must be no more than 7 characters.
11-15	IMFP	I5	The logical file number on IMTAP where the combined freedom matrix resides. (Default: IMFP = 1)
16-20	IMMP	I5	The matrix position no. in the IMFP file where the modal matrix is found. (Default: IMMP = 1)

Repeat this case for all single freedoms desired.

Card 11.4 – Mapping of Combined Freedoms

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	MAPaa	A10	Keyword indicating into which freedom (i.e., translation x, y or z; or rotation θx, θy, θz) the selected rows of the input modal data will be placed.
11-70	Jaa_I	12I5	Row number of the combined freedom matrix that shall be placed in the Ith row of the desired single freedom matrix (I = 1, NJODES) NOTE: If more cards are needed, the format for succeeding cards is 10X, 12I5.

Note: The characters aa will be equal to one of the following pairs of characters, depending upon the freedom being sorted.

aa = TX, TY, TZ, RX, RY, or RZ

Card Set 12.0 – Modal Data in Single Freedom Form (Optional)

Cards 12.1 through 12.4 are repeated for each single freedom selected.

Card 12.1 – Single Freedom Input Definition

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	aa	A10	Keyword indicating to which single freedom the modal data belongs.
11-20	FROM	A10	Descriptive word (optional)
21-30	{ CARD / TAPE }	A10	Keyword indicating modal data read from CARD or TAPE.
31-35	NRO4aa*	I5	Row size of single freedom matrix.
36-40	NCOLaa*	I5	Column size of single freedom.
41-45	ISIaa*	I5	Starting column of input single freedom matrix from which modes will be picked up.
46-50	ISOaa*	I5	Starting column of output single freedom matrix into which modes will be placed.
51-55	NMODaa*	I5	Number of columns to use from the input single freedom matrix starting with column ISIaa.

*The characters aa are the same as those specified in keyword aa.

Card 12.2 - Single Fredoms on Cards

Read this card if columns 21 through 30 on card 12.1 contain the keyword CARD. Repeat this card NROWaa times (I = 1, NROWaa)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-70	A_{IJ}	7E10.3	Single freedom mode shapes read in by row. Each row begins on a new card. (J = 1, NCOLaa) **The freedom A being input must correspond to the keyword on card 12.1 --cols. 1 through 10**

Card 12.3 - Single Freedoms on Tape

Read this card if columns 21 through 30 on card 12.1 contain the keyword TAPE.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	ISTAP	A7,3X	The name of the tape which contains the single freedom modal data. The tape name must begin with an alphabetic character and contain no more than (7) characters.
11-15	ISFP	I5	The logical file on ISTAP where the single freedom matrix will be found.
16-20	ISMP	I5	The matrix position number in ISFP file of the single freedom matrix.

The freedom being input must correspond to the fredom designated by the keyword on on card 12.1.

Card 12.4 - Mapping of Single Freedoms (Optional)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	aa	A10	Keyword indicating the freedom into which the input single freedom will be mapped.
11-70	Jaa_I	12I5	Row number of the input single freedom which is to be placed into the Ith row of the output single freedom. I = 1, NNODES If more cards are needed the format for the cards will be 10X, 12I5.

Note: The characters aa refer to the freedom being sorted and represent one of the pairs of letters TX, TY, TZ, RX, RY, or RZ. If mode shapes are input in single freedom format and this card is omitted, the modal data will be used in the order in which they are read.

Card Set 13.0 - Rigid Surface Mode (Optional)

Card 13.1 - Definition of Rigid Mode

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	RIGID	A10	Keyword indicating rigid surface modes are to be added to the sorted freedoms.
11-15	ISORS	I5	Starting column from which the rigid surface modes are to be added to the sorted freedom matricies.
16-20	NMODRS	I5	Number of rigid surface modes (columns) to be added.

Card 13.2 – Hinge Line Definition

Repeat this card NMODRS times.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	HINGE	A10	Keyword indicating the hinge line location and rotation definition follow. All data is in local axis system.
11-20 21-30	XIHL YIHL	E10.0 E10.0	X and Y coordinates of inboard end point of hinge line. (Local axis)
31-40 41-50	XOHL YOHL	E10.0 E10.0	X and Y coordinates of outboard end point of hinge line. (Local axis)
51-60	THETA	E10.0	Rotation angle of the control surface (Radians).
61-65	IROT	I5	Rotation indicator = 0 rotation along hinge line = 1 rotation is perpendicular to freestream direction.

Card Set 14.0 – Selection of Freedoms for SA Array

Repeat this card for each SA array for this surface.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	SA	A10	Keyword specifying the freedoms to be used for forming the interpolation arrays.
11-15 16-20 21-25	ITX ITY ITZ	I5 I5 I5	Translation indicator = 0, no translation = 1, translation requested
26-30 31-35 36-40	IRX IRY IRZ	I5 I5 I5	Rotation indicator = 0, no rotation = 1, rotation requested

Note: Beam spline – 1 to 3 freedoms may be specified; there must be one translation and zero, one, or two rotations.
Motion axis – 3 freedoms must be specified; one translation and two rotations.
Motion point – 1 to 6 freedoms; (note: for DYLOFLEX users, only 3 freedoms may be used, one translation and 2 rotations.)
Surface spline – 1 freedom; one translation which is normal to the surface.
Polynomial – no modal input required.

Only one of the card sets 15.0 through 19.0 may be specified.

Card Set 15.0 – Beam Spline Method

Card 15.1 – Beam Spline Interpolation Scheme

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	BEAMspline	A10	Keyword indicating Beam Spline interpolation scheme to be used.
11-15	NBEAM	I5	Number of beams. **(NBEAM ≥ 2)**

Card 15.2 – Beam Node Selection

Repeat this card NBEAM times. (I = 1, NBEAM)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-5	NPB_I	I5	Number of nodes on the Ith beam.
6-10	$IEXTRP_I$	I5	Extrapolation indicator **(See sec. 4.4.3)** = 0, no extrapolation = 1, outboard extrapolation = 2, inboard extrapolation = 3, both inboard and outboard extrapolation
11-70	$IP_{I,J}$	12I5	Node location (row number) of the sorted coordinates and modal data which will be associated with the Jth node of the Ith beam. $J = 1, NPB_I$ If more cards are required, their format is (13X, 12I5)

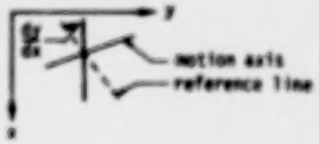
Card Set 16.0 – Motion Axis Method

Card 16.1 – Motion Axis Interpolation Scheme

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	MOTIONAxis	A10	Keyword indicating the Motion Axis interpolation scheme to be used.
11-15	NDEF	I5	Number of motion axis definition points (NDEF ≥ 2)
16-20	IORIEN	I5	Indicator for rotation Rx orientation = 0, freestream = 1, perpendicular to local straight line motion axis

Card 16.2 – Definition Point Data

Repeat this card NDEF times. (I = 1, NDEF)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10 11-20	XRL_I YRL_I	E10.0 E10.0	X and Y coordinates (local axis system) of the motion axis definition points.
21-30	$DYDXRL_I$	E10.0	Slope of the reference line associated with the Ith definition point 

Card Set 17.0 – Motion Point Method

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	MOTIONpt	A10	Keyword indicating the Motion Point interpolation scheme to be used.

Card Set 18.0 – Polynomial Interpolation Method

Card 18.1 – Polynomial Interpolation Scheme

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	POLYnomial	A10	Keyword indicating that the Polynomial scheme to be used.
11-15	IORD	I5	Order of the polynomial (IORD $\leq$ 5)

Card 18.2 – Polynomial Coefficients

Repeat this card NTMODE times (card 4.0).

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-70	C_I	7E10.0	Polynomial Coefficients where (I = 1, NPCOEF) $NPCOEF = \frac{(IORD+1)*(IORD+2)}{2}$

Example:

IORD = 0 coef read for C_{00}

$\delta_z(x,y) = C_{00}$

IORD = 1 C_{00}, C_{10}, C_{01}

$\delta_z(x,y) = C_{00} + C_{10}x + C_{01}y$

IORD = 2 $C_{00}, C_{10}, C_{01}, C_{20}, C_{11}, C_{02}$

$\delta_z(x,y) = C_{00} + C_{10}x + C_{01}y + C_{20}x^2 + C_{11}xy + C_{02}y^2$

IORD = 3 $C_{00}, C_{10}, C_{01}, C_{20}, C_{11}, C_{02}, C_{30}, C_{21}, C_{12}, C_{03}$

$\delta_z(x,y) = C_{00} + C_{10}x + C_{01}y + C_{20}x^2 + C_{11}xy + C_{02}y^2 + C_{30}x^3 + C_{21}x^2y + C_{12}xy^2 + C_{03}y^3$

Card Set 19.0 – Surface Spline Method

Card 19.1 – Surface Spline Interpolation Scheme

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	SURFace	A10	Keyword indicating that the surface spline interpolation scheme to be used.
11-15	NSMTH	I5	Smoothing Indicator (See sec. 4.4.4) = 0, no smoothing = 1, a smoothing value applies to all points = n, n = the number of smoothing values to use (one for each node on planform)

Card 19.2 – Smoothing Values

Read this card only if NSMTH > 0.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-70	$SMTH_I$	7E10.0	Smoothing values where (I = 1, NSMTH)

Card Set 20.0 – Print Option Selection

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	PRINT	A10	Keyword indicating print option is chosen.
11-45	{ SA * / LOCations / MOD* }	3A10	List of keywords indicating the matrices to be printed. Keyword — Matrix Print SA — SP array LOC — Sorted nodal locations $[X,Y,Z]_D$ MOD — Sorted single freedom matricies [TX],[TY],[TZ],[RX],[RY],[RZ]

*Those keywords may be used in any combination.

Card Set 21.0 - End Surface

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$END	A10	Keyword indicating the end of the Ith surface interpolation data.

Repeat $SURFACE (card set 5.0) through $END (card set 21.0) for each surface.

This begins the second phase of the Interpolation Program. Displacements and slopes are generated at given aerodynamic control points. Skip to card set 28.0 if second phase is not desired.

Card Set 22.0 - Modal Output Tape Option (Optional)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	MOTAPe	A10	Keyword indicating the output will be saved in tape.
11-20	IMOTP	A7,3X	Tape name where the interpolated motion ($[\delta_z]$, $[d\delta_z/dx]$, $[d\delta_z/dy]$) will be saved. (Default: IMOTP = 'MODEO) Name must begin with an alphabetic character and must not be greater than 7 characters.

Card Set 23.0 - Interpolation

Repeat card sets 23.0 through 27.0 for each set of output points for which interpolated motion is desired.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$MODE	A10	Keyword indicating the block of input data required for calculating interpolated motion.
11-20	IDM	A10	Mnemonic identification of this set of interpolation data.
21-25	NTMODE	I5	Number of modes to pick up from the SA arrays which will be used for determining the motion at the aerodynamic control points. (Default: Total modes as read from first SA array used.)

Note: A set of output points may use more than one SA array. It is only required that all output points in a set have the same local aerodynamic axes. (See section 5.2.)

Card Set 24.0 – Aerodynamic Surface Transformation

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	AEROT	A5,5X	Keyword indicating the aerodynamic transformation data.
11-20	AEROX	E10.3	X, Y, Z — Coordinates of the origin of the aerodynamic surface (in the reference axis system).
21-30	AEROY	E10.3	
31-40	AEROZ	E10.3	
41-50	XSH	E10.3	X, Z — Offset of the aerodynamic surface in the local (structural) surface axis.
51-60	ZSH	E10.3	

Card Set 25.0 – Definition of Output Locations

Card 25.1 – Output Locations

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	OUTLO	A10	Keyword indicating output locations are input from cards or tape.
11-20	READ FROM	A10	Descriptive word (optional)
21-30	CARD / TAPE	A10	Keyword indicating locations are read from CARD or TAPE.
31-40	LOCal / REFerence	A10	Keyword indicating output locations defined in LOCAL or REFerence axis systems.
41-45	NOUTLO	I5	Number of output points.
46-50	INDD	I5	Indicator for generating slopes • 0, no slopes • 1, dz/dx • 2, dz/dy • 3, dz/dx and dz/dy
51-55	INDG	I5	Indicator for local dihedral correction option (see sec. 5.2) • 0 skip the option • 1 first dihedral angle will be used for all output points • 2 a dihedral angle will be read for each output point.

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Card 25.2 – Output Locations on Cards

Read this card if columns 21 through 30 on card 25.1 contain keyword CARD. Repeat this card NOUTLO times, one card for each node. (I = 1, NOUTLO)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10 11-20 21-30	XO_I YO_I ZO_I	E10.0 E10.0 E10.0	X, Y, and Z coordinates for the Ith output point.
31-35	IS_I	I5	Surface number (SA array) where output point is located.
36-40	blank	5X	
41-50	$GAMMA_I$	E10.0	Local orientation of normal component in radians. (Measured from reference axis system)

Card 25.3 – Output Locations on Tape

Read if columns 21 through 30 on card 25.1 contain the keyword TAPE

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	IOPTP	A7,3X	Name of the tape containing the output point locations. Tape name must begin with an alphabetic character and must contain no more than 7 characters.
11-15	IOPFP	I5	The file position number on IOPTP where output point data is found. (Default: 1)
16-20	IOPMP	I5	Matrix position number in the IOPFP file where output point data is found. (Default: 1)
21-25	IGAM	I5	Dihedral matrix indicator = 0, no matrix of dihedral angles will be read = 1, matrix of dihedral angles will be read following matrix of output locations

Card 25.4 – Surface Indicators

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-70	IS_I	14I5	Surface number (SA array) which will be used to interpolate for this output point. (I = 1, NOUTLO)

Card Set 26.0 – Print Option

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	PRINT	A5,5X	Keyword indicating matricies to be printed.
11-40	SA* or NOD	3A10	List of keywords in any order indicating the matrices to be printed.
			Keyword — Matrix printed
			SA — SA array(s) used to generate output mode shapes.
			NOD — Interpolated output node shape matrix with output locations.

*These keywords may be used in any combination

Card Set 27.0 – End Output Set

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$END	A10	Keyword indicates the end of the Ith set of output points.

Repeat $MODE (card set 23.0) through $END (card set 27.0) for each set of output points desired.

Card Set 28.0 – Program Terminator

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$QUIT	A10	Keyword indicating the last data for the interpolation program has been read.

Requirements or Function	Keywords and/ or Variables	Card Format	Reference Card Set(s)
	$INTErpolation	A10	1.0
Job title (optional)	TITLE	A10,7A10	2.1
Comment Card (optional)	C_	A2,8X,7A10	2.2
Definition of magnetic file on which SA arrays will be written or read. (Optional)	SATAPe ISATP	A10,A7,3X	3.0
	If SA arrays have already been generated, and only output shapes are required, go to card set 22.0.		
Total number of nodes to use for interpolation (optional)	TNODE NTNODE	A10,I5	4.0
	Repeat card sets 5.0 through 21.0 for each surface.		
Surface definition	$SURFace ISURF blanks ID	A10,I5 5X,A10	5.0
Surface transformation data (Optional)	TRANSformation data	A10	6.1
Transformation data (required if card 6.1 is used)	XR YR ZR XRANG YRANG ZRANG ORDER aaa	6E10.0,A10	6.2
	If POLYNOMIAL method is selected, skip to card set 14.0		
Definition of nodal coordinate data	NODEs read from {CARD / TAPE} {LOCal / REFerence} NNODEI blanks {ENGLISH / METRIC}	A10,10X,2A10, I5,5X,A10	7.1
	Repeat card 7.2 NNODEI times, one node per card. (I=1, NNODEI)		
Required if nodal coordinates read from CARD (card 7.1)	XN_I YN_I ZN_I RXN_I RYN_I RZN_I	6E10.0	7.2
Required if nodal coordinates read from TAPE (card 7.1)	INTAP INFP INNP IROT	A7,3X,3I5	7.3

Requirements or Function	Keywords and/or Variables	Card Format	Reference Card set(s)
Input for nodal mapping (Optional)	MAPNode NNODES	A10,I5	8.1
Mapping values (required if card 8.1 is used)	$INAPND_I$ (I = 1, NNODES)	16I5	8.2
Scalers for sorted freedoms (Optional)	SCALar SCALTX SCALTY SCALTZ SCALRX SCALRY SCALRZ	A10,6E10.0	9.0
Modal input	MODEs FROM (Optional) IISURF	2A10,I5	10.0
Input of modes in combined freedom form (Optional)	COMBined from $\left(\begin{matrix}\text{CARD}\\\text{TAPE}\end{matrix}\right)$ NROWCM NCOLCM ISICM ISOCM NPRDCM	3A10,5I5	11.1
	Repeat card NROWCM times (I = 1, NROWCM)		
Required if mode shapes read from CARD (card 11.1)	COM_{IJ} (J = 1,NCOLCM)	7E10.0	11.2
Required if mode shapes read from TAPE (card 11.1)	IMTAP IMFP IMPP	A7,3I,2I5	11.3
	Note: The characters aa are used to refer to the particular freedom of interest. aa = TX, TY, TZ, RX, RY, or RZ		
Mapping of combined freedoms. Required if modes are input in combined freedom form	MAPaa Jaa_I (I = 1,NAFDES)	A10,12I5	11.4
	Note: If additional cards are needed for the row designation variables Jaa_I, the format for succeeding cards is 10X,12I5. Card 11.4 is repeated for each type of freedom that is selected from the combined modes.		

Requirements of Function	Keywords and/or Variables	Card Format	Reference Card Set(s)
	Cards 12.1 through 12.4 are repeated for each single freedom selected.		
Input modes in single freedom form (Optional)	aa from (CARD / TAPE) NROWaa NCOLaa ISIaa ISOaa NMODaa	3A10,5I5	12.1
	Repeat card 12.2 NROWaa times (I = 1,NROWaa)		
Required of mode shapes read from CARD (card 12.1)	$A_{I,J}$ (J = 1,NCOLaa)	7E10.0	12.2
Required of mode shapes read from TAPE (card 12.1)	ISTAP ISFP ISMP	A7,3I,2I5	12.3
Mapping of single freedom (Optional)	MAPaa Jaa_I (I = 1,NNODES)	A10,12I5	12.4
Rigid surface mode (Optional)	RIGID ISORS NMODRS	A10,2I5	13.1
	Repeat card 13.2 NMODRS times		
Hinge line definitions (required if card 13.1 is used)	HINGE XIHL YIHL XOHL YOHL THETA IROT	A10,5E10.0,I5	13.2
	Repeat card set 14.0 for each SA array desired for this surface		
Selection of freedoms for SA array	SA ITX ITY ITZ IRX IRY IRZ	A10,6I5	14.0
	Only one of the card sets 15 through 19 may be specified		
Selection of BEAM SPLINE method	BEAMspline NBEAM	A10,I5	15.1
	Repeat card 15.2 NBEAM times (I = 1,NBEAM)		
Selection of beam nodes	NPB_I $IEXTRP_I$ $IP_{I,J}$ (J = 1,NPB_I)	2I5,12I5	15.2
	Note: If more cards are required for $IP_{I,J}$ variables, the format is 10X,12I5		
Selection of MOTION AXIS method	MOTIONAxis NDEF IORIEN	A10,2I5	16.1

Requirements or function	Keyword and/or Variables	Card Format	Reference Card Set(s)
	Repeat card 16.2 NDEF times (I = 1,NDEF)		
Axis definition point data	XRL_I YRL_I DYDXRL,	3E10.0	16.2
Selection of MOTION POINT method	MOTIONpt	A10	17.0
Selection of POLYNOMIAL method	POLYnomial IORD	A10,I5	18.1
	Repeat card 18.2 NTMODE times (card set 4.0)		
Polynomial coefficients	C_I (I = 1,NPCOEF) where NPCOEF = [(IORD+1)*(IORD+2)/2]	7E10.0	18.2
Selection of SURFACE SPLINE method	SURFace NSMTH	A10,I5	19.1
Smoothing values (Only if NSMTH > 0)	$SMTH_I$ (I = 1,NSMTH)	7E10.0	19.2
	Print options may appear in any order on card set 20.0		
Print option selection	PRINT { SA / LOCation / MOD }	A10,3A10	20.0
End of surface data	END	A10	21.0

Requirements or Function	Keyword and/or Variables	Card Format	Reference Card Set(s)
	Omit card sets 22.0 through 27.0 if interpolated mode shapes are not desired.		
Output motion to be saved on magnetic file (optional)	MOTAPe IMOTP	A10,A7,3X	22.0
	Repeat card sets 23.0 through 27.0 for each set of output points		
Keyword indicating set of input data for calculating interpolated motion	SMODE IDA NTMODE	2A10,I5	23.0
Aerodynamic Surface transformation	AEROT AERO1 AERO1 AERO2 XSH YSH	A1,5X,5E10.0	24.0
Definition of output locations	OUTLO read from (CARD / TAPE) (Local / Difference) NOUTLO INDD INDG	4A10,3I5	25.1
	Repeat card 25.2 NOUTLO times, one card for each output node (I = 1,NOUTLO)		
Required if output locations read from CARD (card 25.1)	$R1_I$ $Y0_I$ $Z0_I$ $I5_I$ blanks $GAMMA_I$	3E10.0,I5,5X, E10.0	25.2
Required if output locations read from TAPE (card 25.1)	IOPTP IOPFP IOPWD IOAM	A7,3X,3I5	25.3
Required if output locations read from TAPE (card 25.1)	$I5_I$ (I = 1,NOUTLO)	14I5	25.4
	Print options may appear in any order on card set 26.0.		
Print Options	PRINT (SA / MODE)	A1,5X,3A10	26.0
End of output set	SEND	A10	27.0
Program terminator	EQUIT	A10	28.0

6.5.3 MAGNETIC FILE INPUT

The matrices on magnetic files must be written in the READTP/WRTETP format (ref. 1). There are six types of matrices the user may input from magnetic file: combined freedoms, single freedoms, input node locations, nodal orientation angles, output locations of aerodynamic control points, and unit normal orientations. The use of magnetic files for input depends upon how the six types of matrices are specified in card input data (cards 7.1, 11.1, 12.1, 25.1) of keywords, NODEs, COMBIned, TX, TY, TZ, RX, RY, RZ, and OUTLOcations. A keyword TAPE on these cards indicates input is from magnetic files. If this is the case, the magnetic file name, the file position number, and the matrix position number in the specified file position must be specified. Each input matrix may be read from a magnetic file having the same or different name. The L215 program will rewind the magnetic file before reading each matrix specified. Figure 19 describes the input files.

6.6 OUTPUT DATA

6.6.1 PRINTED OUTPUT

The input data for the L215 program will be echo printed. Other printed output, all of which is optional, is discussed below:

- The input mode shapes in sorted single freedoms
- The input node coordinates and rotation angles
- The interpolation functional coefficient matrix array
- The output aerodynamic control point coordinates
- The interpolated mode shapes at the aerodynamic control points

6.6.2 MAGNETIC FILES OUTPUT

L215 will write on as many as three magnetic files, SATAP, MOTAP, and SCRAND. The latter is a scratch random file. The matrices contained on magnetic files SATAP and MOTAP are written by the WRTETP subroutine, and the matrices contained on file SCRAND are written by WRITMS subroutine.

SATAP

The magnetic file name SATAP is the default name and may be changed by input card 3.0. The matrices written on SATAP are described in figure 20.

MOTAP

The name MOTAP is the default name for the magnetic file produced when mode shapes are generated at output aerodynamic control points. The name MOTAP may be changed by input card 24.0. The matrices written on MOTAP are described in figure 21.

File Structure For INTAP

[x, y]	A NNODEI x 2 matrix if local axis coordinates are used (card 7.1)
or	
[x, y, z]	A NNODEI x 3 matrix if reference axis coordinates are used (card 7.1)
[ϕ, σ, ψ]	A NNODEI x 3 matrix of node orientation angles; read if IROT $\neq$ 0 (card 7.3)

File Structure For IMTAP

[ϕ]	A NROWCM x NCOLCM matrix of modal data which contains unsorted freedoms (card 12.1)

File Structure of IOPTP

[xo, yo]	A NOUTLO x 2 matrix of local axis system coordinates of the output points
or	
[xo, yo, zo]	A NOUTLO x 3 matrix of reference axis system coordinates of the output points
[γ]	A NOUTLO x 1 matrix of γ angles (radians)

File Structure For ISTAP

[ϕ_{δ_x}]	A NROWTX x NCOLTX matrix of modal data representing the δ_x freedoms
[ϕ_{δ_y}]	A NROWTY x NCOLTY matrix of modal data representing the δ_y freedoms
[ϕ_{δ_z}]	A NROWTZ x NCOLTZ matrix of modal data representing the δ_z freedoms
[ϕ_{θ_x}]	A NROWRX x NCOLRX matrix of modal data representing the θ_x freedoms
[ϕ_{θ_y}]	A NROWRY x NCOLRY matrix of modal data representing the θ_y freedoms
[ϕ_{θ_z}]	A NROWRZ x NCOLRZ matrix of modal data representing the θ_z freedoms

The above matrices may appear in any order (see cards 12.1 through 12.3).

Figure 19. — Input File Structures

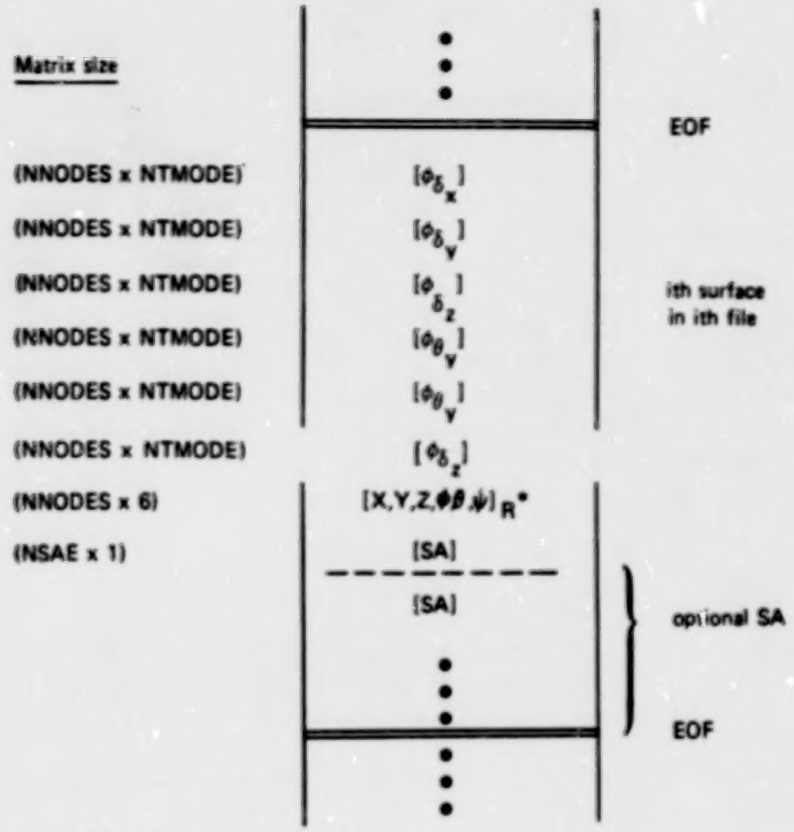

Figure 20. – Magnetic File Map of SATAP

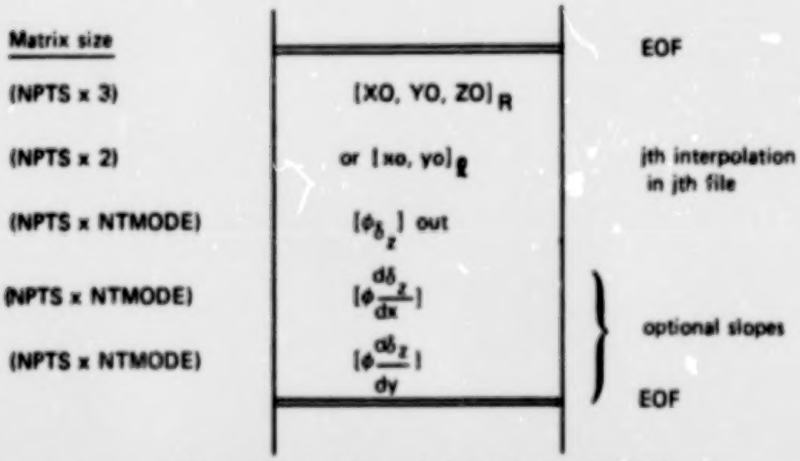

Figure 21. – Magnetic File Map of MOTAP

6.7 RESTRICTIONS

The primary program restrictions are listed below:

- For the beam spline method, output slopes $d\delta_z/dy$ in the y-axis direction will be generated only if RX motions were specified in the SA array generation.
- Streamwise interpolation using the beam spline method must take place over a minimum of two beams.
- The problem size limitation is governed by the maximum size restriction of the SA array, which is 10 000 words. The size of the SA array is a function of interpolation method, number of nodes, and number of modes (see section 6.4). A guide to the selection of allowable input variable sizes for three methods is shown in figure 22. The size limitation is applied to each individual surface.

6.8 DIAGNOSTICS

6.8.1 FATAL ERRORS

All fatal errors detected by the program will result in the printing of a diagnostic error message. These messages are self-explanatory and are of the following format.

```
******** FATAL ERROR nnnnn
         DIAGNOSED WHILE EXECUTING ROUTINE name
         any additional error messages
```

where "nnnnn" is the diagnostic error number and 'name' is the name of the routine in execution when the error was detected. Additional explanatory messages will be appended to the two standard error message lines.

The following list is a brief description of each diagnostic error number:

1. End-of-record card was encountered before $END card.
2. Keyword (aaaaaaaaaa) with code number (nnnnn) is not recognized.
3. FETAD error number (nnnnn) returned.

   Error number = 1, illegal tape name/number

   = 2, buffer too small

   = 3, maximum number of files have already been defined, 49 allowed
4. Method of interpolation not specified.

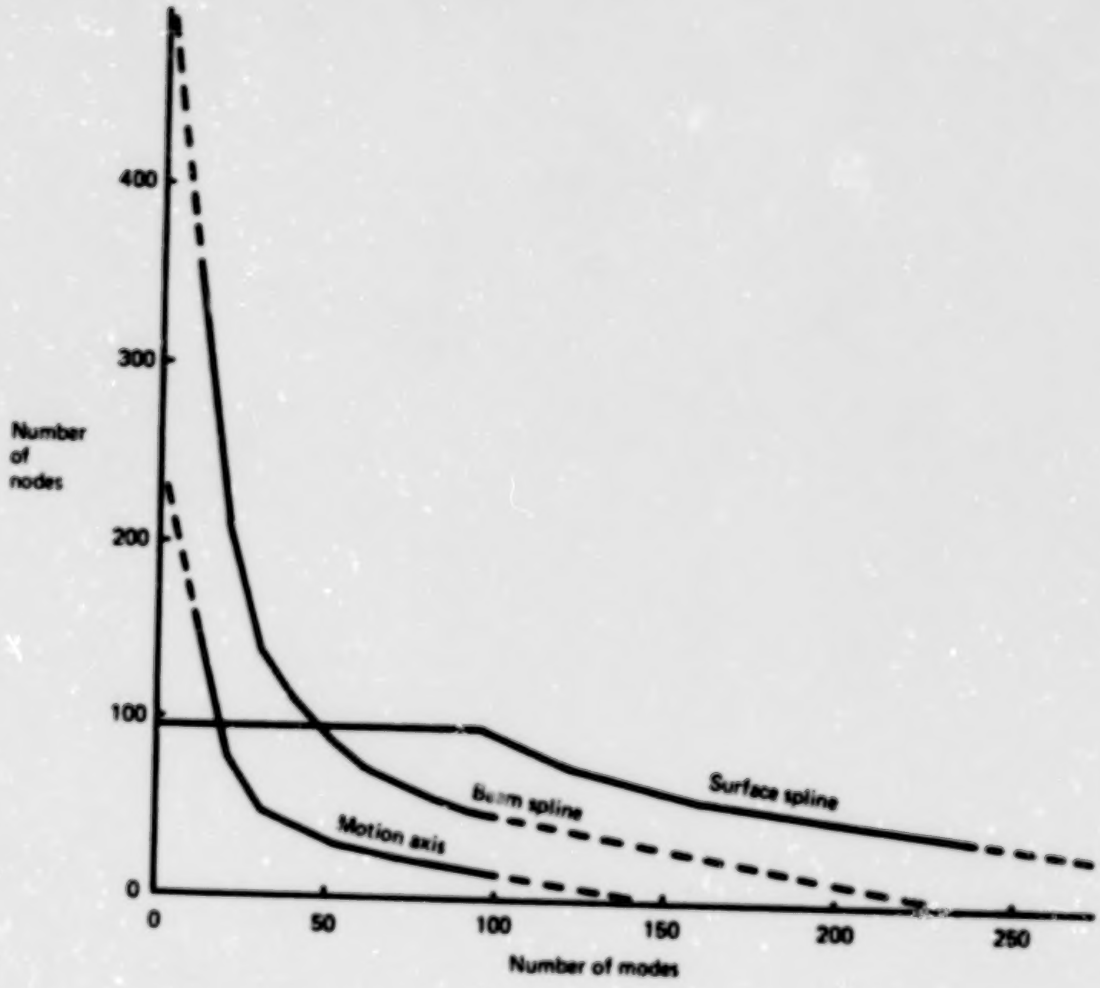

Figure 22. – Size Limitations

5. Number of available field length is xxxxx octal.
   Number of required field length is xxxxxx octal.
   Therefore, add the difference xxxxxx octal to your current field.

6. Input volume (aaaa) does not equal keyword CARD or TAPE.

7. WRTETP error number (nnnnn) returned.

Error code	= 0,	No errors are detected during writing.
	= 1000+I,	A forward space file error occurred, where I is the number of file marks remaining to be skipped when an end- of-information was encountered.
	= 2,	The number of matrices or files to be skipped before writing starts is less than zero.
	= 3,	The dimensioned number of rows in the matrix is less than or equal to zero.
	= 3000+I,	A forward space record error occurred, where I is the number of records remaining to be skipped when either an end-of-file or an end-of-information was encountered.
	= 4,	The actual number of rows is greater than the dimensioned number of rows in the matrix.
	= 6,	The number of rows (M) in the matrix times the number of columns (N) is greater than the buffer size.

8. READTP error number (nnnnn) returned.

Error code	= 0,	No errors are detected during reading.
	= 1000+I,	A forward space file error occurred, where I is the number of file marks remaining to be skipped when an end-of-information was encountered.
	= 2,	The number of matrices or files to be skipped before reading starts is less than zero.
	= 3,	The dimensioned number of rows in the matrix is less than zero.
	= 3000+I,	A forward space record error occurred, where I is the number of records remaining to be skipped when either an end-of-file or end-of-information was encountered.

= 4, Number of rows in the matrix is greater than the dimensioned row size in the program.

= 5, The name check failed.

= 6, The number of rows (M) in the matrix times the number of columns (N) is greater than the buffer size, or M or N ≤ 0.

= 7, An end-of-file was read. If it occurs while reading the matrix ID, no information is stored in the user's area. If it occurs while reading the matrix, the ID information will be stored. Note that the records will always be in pairs, and an end-of-file should always be encountered with the ID RECORD.

9. Input matrix for (aaaaaaaaaa) row or column size (nnnnn x nnnnn) is larger than row or column size specified (nnnnn x nnnnn).

10. Parent surface (nnnnn) SA array does not have degree of freedom (TX, TY, TZ, RX, RY, or RZ) specified.

11. AINTL error code (aaaaaaaaaa) returned:
Error code ≥ 0, No error

< 0, Error of the form 10H°nnnnnnnnxx, nnnnnnnn=routine name, xx=error no.

= 10H°AINTL 1, Interpolation coefficient array type not recognizable

12. AINTG error code (aaaaaaaaaa) retuned:
Error code ≥ 0, No error

< 0, Error of the form 10H°nnnnnnnnxx, nnnnnnnn=routine name, xx=error no.

= 10H°AINTL 1, Interpolation coefficient array type not recognizable

13. Translation X and rotation X specified. Not legal.

14. Translation Y and rotation Y specified. Not legal.

15. Translation Z and rotation Z specified. Not legal.

16. Translation X not allowed.

17. More than one (nnnnn) translation freedom specified.

18. More than two rotation freedoms specified.

19. No coordinates to work on. Coordinates not input.

20. More than one (nnnnn) freedom specified.

21. No freedom specified.

22. INODFR error number (nnnnn) returned.

    Error number = 1, Input volume not specified

    = 2, FETAD error detected

    = 3, READTP error detected

    = 4, Input matrix size not valid

23. PARENT error number (nnnnn) returned:

    Error number = 1, READTP error detected

    = 2, degree of freedom not specified

    = 3, AINTL error detected

26. BEAMI error code (aaaaaaaaaa) returned; for error code, see BEAMI listing.

27. MOTAXI error code (aaaaaa) returned; for error code, see MOTAXI listing.

28. MOTPTI error code (aaaaaaaaaa) returned; for error code, see MOTPTI listing.

29. POLYI error code (aaaaaaaaaa) returned; for error code, see POLYI listing.

30. PLATEI error code (aaaaaaaaaa) returned; for error code, see PLATEI listing.

31. Number of SA arrays for this surface is greater than six.

32. Number of beams (nnnnn) is less than two.

33. Order of polynomial is less than zero.

34. Translation freedom not specified.

35. Rotation-translation order indicators not X, Y, or Z.

36. GENMOD error number (nnnnn) returned:

Error number = 1, READTP error while reading SA array

= 2, AINTL error

= 3, AINTG error

= 4, WRTETP error while writing geometry

= 5, WRTETP error while writing Z

= 6, WRTETP error while writing DZ1

= 7, WRTETP error while writing DZ2

37. Rotation order X,Y,Z not specified correctly (aaaaaaaaaa)

6.8.2 WARNING MESSAGES

All warning messages will be self-explanatory and printed in the following format:

```
******** WARNING MESSAGE nn
         DIAGNOSED WHILE EXECUTING ROUTINE name
         any additional warning messages
```

where "nn" is the warning message number and "name" is the name of the routine in execution when the warning was detected. Additional explanatory messages will be appended to the two standard warning message lines.

The following list is a brief description of each warning message number:

1. End-of-record card encountered before $END card. The $END card is assumed.

2. The maximum number of TITLE cards has already been read. The above card is treated as a comment.

3. Parent surface number (nnnnn) is greater than or equal to current surface number (nnnnn). Parent surface modes are not calculated.

4. Input matrix for (aaaaaaaaaa) row or column size (nnnnn x nnnnn) does not equal row or column size specified (nnnnn x nnnnn).

7.0 SAMPLE PROBLEM

7.1 DESCRIPTION OF SAMPLE PROBLEM

The sample problem used here consists of a high aspect ratio wing that has three movable control surfaces (fig. 23). Eight vibrational mode shapes were calculated using an elastic axis idealization. To the basic set of freedoms, three control surface rotation freedoms were added. The motion axis interpolation method was used for all surfaces.

The mode shapes were defined at 34 node points where coordinates were input in the reference axis system. Nodal locations were on tape and were in a tip to root order. Mode shapes for the parent surface (main wing surface) were on tape in a combined freedom format. Three freedoms per node were generated (δ_z, θ_x, θ_y). Input modes were defined parallel and perpendicular to the motion axis.

The parent surface motion axis was defined with eleven motion axis definition points. The hinge lines were used for the motion axes of each control surface.

A total of 36 output points were read from cards in the local axis system coordinates. The local aerodynamic and local structural axes are the same. Output motions requested were surface vertical translations (δ_z), slope parallel to the freestream ($d\delta_z/dx$), and slope perpendicular to the freestream ($d\delta_z/dy$).

Boeing Commercial Airplane Company
P.O. Box 3707
Seattle, Washington 98124
May, 1977

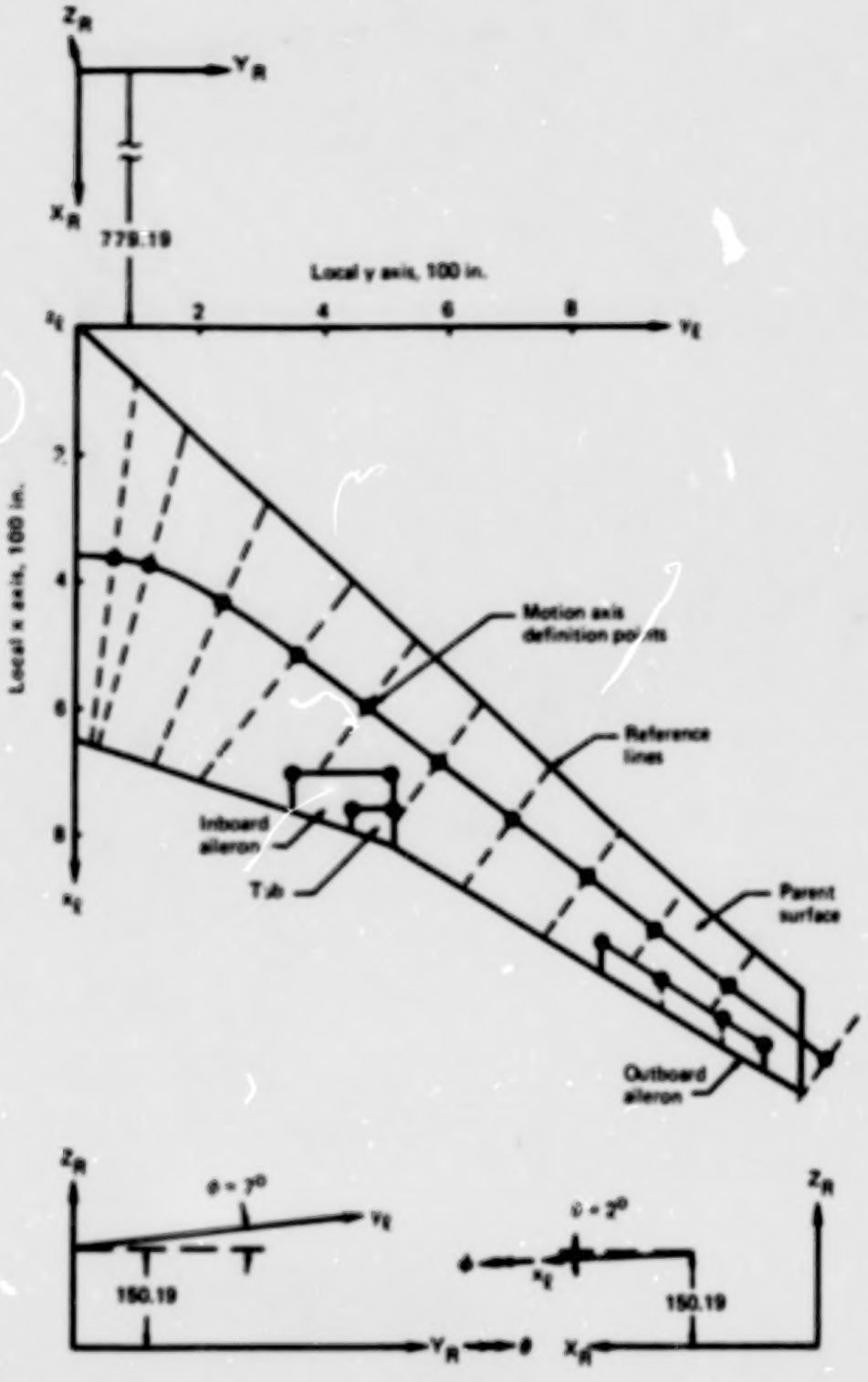

Figure 23. – Sample Problem

Sample Problem Card Input

```
$INPTAPE,ATTIN PROGRAM
TITLE    WING ASPECT RATIO WING WITH 11 MODAL POSITIONS
C        DEFINE SA TAPE FOR OUTPUT
SATAPE   SATAP
C        DEFINE TOTAL NUMBER OF MODES
C        4 STRUCTURAL MODES + 3 CONTROL SURFACE POSITIONS
TMODE      11
SSURFACE    1     MAIN WING
TRANSFORM
779.19     0.0       150.09    7.        7.        0.0       GROSS  YNZ
MODES    FROM      TAPE      REFERENCE    SA     ENGLISH
MODETP      1    1
C        CHANGE MODE ORDERING FROM TIP TO ROOT TO ROOT TO TIP
RAPSONS
   34   33   32   31   30   29   28   27   26   25   24   23   22   21
   20   19   18   17   16   15   14   13   12   11   10    9    8    7
    6    5    4    3    2    1
MODES
CHANGED  FROM      TAPE        182    0    1    1    0
MODETP      1    7
MAPTI       1    2    3    4    5    6    7    8    9   10   11   12
           13   14   15   16   17   18   19   20   21   22   23   24
           25   26   27   28   29   30   31   32   33   34
MAPXX      35   36   37   38   39   40   41   42   43   44   45   46
           47   48   49   50   51   52   53   54   55   56   57   58
           59   60   61   62   63   64   65   66   67   68
MAPXY      69   70   71   72   73   74   75   76   77   78   79   80
           81   82   83   84   85   86   87   88   89   90   91   92
           93   94   95   96   97   98   99  100  101  102
SA                1    1    1
MOTIONRATE   11    1
391.77     98.7      =.1444
376.5      117.4     =.2000
427.36     276.8     =.5776
512.14     352.2     =.75041
591.44     406.6     =.75041
685.94     507.0     =.75041
773.63     704.4     =.75041
861.91     821.8     =.7431
948.78     939.2     =.7433
1036.24    1056.6    =.7433
1195.0     1211.9    =.7433
PRINT    LOCATIONS
PRINT    MODE
BEND
SSURFACE    2     INBD. AIL.
TRANSFORM
779.19     0.0       150.09    7.        7.        0.0       INDPA  YNZ
C        HINGES ON HINGE LINE
MODES    FROM      LAST      LOCAL        7
700.     950.      0.0
700.     935.      =.0
C        PERCENT SURFACE IS MAIN WING SURFACE
MODES    FROM         1
RIGID       9         1
HINGE    700.      950.      700.      935.      1.0
```

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```
SA                              1    1    1
MOTIONAXIS    2    0
700.       350.       0.
700.       515.       0.
PRINT      SA
PRINT      LOCATIONS
PRINT      MODE
$END
$SURFACE       3     I.A. TAB
TRANSFORM
779.19     0.0        150.09     7.+        2.         0.0        ORDER  YXZ
C          NODES ON HINGE LINE
NODES      FROM       CARDS      LOCAL          2
750.5      445.0      0.0
750.5      515.0      0.0
C          PARENT SURFACE IS INBOARD AIL.
NODES      FROM            2
RIGID        11     1
HINGE      750.5      445.0      750.5      515.       1.0
SA                              1    1    1
MOTIONAXIS    2    0
750.5      445.0      0.
750.5      515.0      0.
PRINT      LOCATIONS
PRINT      MODE
$END
$SURFACE       4     OUTBD. AIL
TRANSFORM
779.19     0.0        150.09     7.         2.         0.0        ORDER  YXZ
C          NODES ON HINGE LINE
NODES      FROM       CARD       LOCAL          4
965.0      850.0      0.0
1027.264   950.0      0.0
1089.528   1050.0     0.0
1130.0     1115.0     0.0
C          PARENT SURFACE IS MAIN WING SURFACE
NODES      FROM            1
RIGID        10     1
HINGE      965.0      850.0      1130.0     1115.0     1.
SA                              1    1    1
MOTIONAXIS    2    0
 965.       850.       0.
1130.      1115.       0.
PRINT      LOCATION
PRINT      MODE
$END
MOTAPE     MODEOUT
$MODE      747 WING
AEROT      779.19     0.0        150.09
OUTLO      READ FROM CARD        LOCAL          36     3
157.8      96.9       0.0             1
334.0      96.9       0.0             1
534.3      96.9       0.0             1
665.1      96.9       0.0             1
318.6      288.2      0.0             1
461.4      288.2      0.0             1
```

623.8	246.2	0.0	1
729.8	246.2	0.0	1
472.8	471.6	0.0	1
583.6	471.6	0.0	1
709.6	471.6	0.0	2
791.8	471.6	0.0	1
620.1	642.1	0.0	1
711.0	642.1	0.0	1
814.3	642.1	0.0	1
861.8	642.1	0.0	1
753.5	795.1	0.0	1
829.5	795.1	0.0	1
915.9	795.1	0.0	1
972.4	795.1	0.0	1
861.3	926.5	0.0	1
924.8	926.5	0.0	1
1001.3	926.5	0.0	1
1049.9	926.5	0.0	4
948.2	1032.5	0.0	1
1003.9	1032.5	0.0	1
1069.6	1032.5	0.0	1
1112.4	1032.5	0.0	4
1008.5	1110.4	0.0	1
1060.6	1110.4	0.0	1
1119.7	1110.4	0.0	1
1158.4	1110.4	0.0	4
1044.6	1158.0	0.0	1
1095.2	1158.0	0.0	1
1150.4	1158.0	0.0	1
1186.4	1158.0	0.0	1

PRINT
SEND
QUIT
NODE

Sample Problem Output

```
*********************************************************
*                                                       *
*   PROGRAM INTERPA VERSION 11/27/75                    *
*   BEGINNING EXECUTION ON THE BCS 6600.                *
*   DATE OF RUN IS  76/10/14.                           *
*   TIME OF RUN IS 20. 4.31                             *
*                                                       *
*********************************************************
   ($INTERPOLATION PROGRAM                                                  )
   ($TITLE     HIGH ASPECT RATIO WING WITH 11 MODAL FREEDOMS                )
   ($C         DEFINE SA TAPE FOR OUTPUT                                    )
   ($SATAPE    SATAP                                                        )

        TAPE NAME ($SATAP  ) WHERE SA ARRAYS ARE STORED.

   ($C         DEFINE TOTAL NUMBER OF NODES                                 )
   ($C         8 STRUCTURAL NODES + 3 CONTROL SURFACE FREEDOMS              )
   ($NODE        11                                                         )

        TOTAL NUMBER OF NODES IS    11

   ($SURFACE     1     MAIN WING                                            )
         SURFACE NUMBER (    1) MNEMONIC IDENTIFICATION IS (MAIN WING )

   ($TRANSFORM                                                              )
                      TRANSLATION                    ROTATION (DEGREES)
              X             Y             Z          PHIX          PHIY          PHIZ
          7.792E+02     .0          1.501E+02    7.000E+00     2.000E+00     .0

             --- --------- ROTATION -----------          TRANSLATION

            9.993978E-01     .0          -3.489950E-02    7.791900E+02
            4.253170E-03    9.925462E-01   1.217951E-01     .0
            3.463936E-02   -1.218693E-01   9.919415E-01    1.500900E+02

   ($NODES      FROM       TAPE       REFERENCE     34      ENGLISH          )
         NODE COORDINATES ARE INPUT FROM (TAPE      ) IN (REFERENCE ) AXIS FRAME IN THE (ENGLISH    ) UNIT SYSTEM.
         NUMBER OF NODES TO BE READ IS (    34)

         TAPE NAME       =   MOD
         FILE POSITION   =      1
         MATRIX POSITION =      1
         ROTATION MATRIX INDICATOR =    -1
```

```
(C        CHANGE NODE ORDERING FROM TIP TO ROOT TO ROOT TO TIP                  )
(MAPNODES                                                                       )

      NUMBER OF NODES SELECTING   34

    34   33   32   31   30   29   28   27   26   25   24   23   22   21
    20   19   18   17   16   15   14   13   12   11   10    9    8    7
     6    5    4    3    2    1
(NODES                                                                          )
(COMBINFO  FROM       TAPE        102    8    1    1    8                     )
       TAPE NAME       =   NODEIP
       FILE POSITION   =     1
       MATRIX POSITION =     7
       ROTATION MATRIX INDICATOR =    -0

(MAPTZ          1    2    3    4    5    6    7    8    9   10   11   12      )
               13   14   15   16   17   18   19   20   21   22   23   24
               25   26   27   28   29   30   31   32   33   34
(MAPRX         35   36   37   38   39   40   41   42   43   44   45   46      )
               47   48   49   50   51   52   53   54   55   56   57   58
               59   60   61   62   63   64   65   66   67   68
(MAPRY         69   70   71   72   73   74   75   76   77   78   79   80      )
               81   82   83   84   85   86   87   88   89   90   91   92
               93   94   95   96   97   98   99  100  101  102
(SA                      1    1    1                                         )
       SA(1) SELECTED FREEDOMS ARE  0 0 1 1 1 0

(MOTIONAXIS   11    1                                                         )
       M O T I O N    A X I S    SCHEME

       NUMBER OF DEFINITION POINTS =    11
       INDICATOR FOR ROTATION RX ORIENTATION (    1)
                 EQUAL 0, FREESTREAM
                 NOT EQUAL 0, PERPENDICULAR TO LOCAL STRAIGHT LINE MOTION AXIS

            X-LOC        Y-LOC        SLOPE

      1   3.638E+02    5.870E+01   -1.444E-01
      2   3.765E+02    1.174E+02   -2.888E-01
      3   4.274E+02    2.348E+02   -5.776E-01
      4   5.121E+02    3.522E+02   -7.504E-01
      5   5.974E+02    4.696E+02   -7.504E-01
      6   6.855E+02    5.870E+02   -7.504E-01
      7   7.736E+02    7.044E+02   -7.504E-01
      8   8.619E+02    8.218E+02   -7.433E-01
      9   9.488E+02    9.392E+02   -7.433E-01
     10   1.038E+03    1.057E+03   -7.433E-01
     11   1.150E+03    1.211E+03   -7.433E-01
(PRINT      LOCATIONS                                                         )
       PRINT OPTION IS     2 (LO        )(          )(          )

(PRINT      MODE                                                              )
       PRINT OPTION IS     6 (MO        )(          )(          )

(END                                                                            )
```

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********** TITLE **********

TITLE HIGH ASPECT RATIO WING WITH 11 MODAL FREEDOMS

INPUT MODE SHAPES TRANSLATION - Z

POS	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	1.000E+00 .0	1.555E+02	-5.815E-02	2.275E-02	2.972E-02	-1.130E-01	-1.737E-02	2.010E-02	.0	.0
2	1.000E+00 .0	1.555E+02	-5.788E-02	2.251E-02	2.924E-02	-1.101E-01	-1.668E-02	1.911E-02	.0	.0
3	1.000E+00 .0	1.555E+02	-5.687E-02	2.159E-02	2.743E-02	-9.939E-02	-1.413E-02	1.478E-02	.0	.0
4	1.000E+00 .0	1.555E+02	-5.501E-02	1.991E-02	2.420E-02	-7.991E-02	-9.663E-03	7.285E-03	.0	.0
5	1.000E+00 .0	1.478E+02	-5.482E-02	1.899E-02	2.272E-02	-7.100E-02	-7.444E-03	3.671E-03	.0	.0
6	1.000E+00 .0	1.190E+02	-5.253E-02	1.479E-02	1.448E-02	-2.725E-02	4.326E-03	-1.460E-02	.0	.0
7	1.000E+00 .0	1.091E+02	-5.118E-02	1.315E-02	1.078E-02	-9.103E-03	9.374E-03	-2.206E-02	.0	.0
8	1.000E+00 .0	9.350E+01	-4.842E-02	1.030E-02	3.947E-03	2.186E-02	1.835E-02	-3.476E-02	.0	.0
9	1.000E+00 .0	6.350E+01	-4.018E-02	3.860E-03	-1.313E-02	9.215E-02	3.892E-02	-6.125E-02	.0	.0
10	1.000E+00 .0	2.940E+01	-2.921E-02	-1.331E-03	-3.430E-02	1.541E-01	6.281E-02	-8.710E-02	.0	.0
11	1.000E+00 .0	2.300E+01	-2.752E-02	-2.044E-03	-4.757E-02	1.623E-01	6.627E-02	-9.036E-02	.0	.0
12	1.000E+00 .0	-2.280E+01	-4.021E-03	-8.193E-03	-7.384E-02	2.296E-01	9.825E-02	-1.104E-01	.0	.0
13	1.000E+00 .0	-5.050E+01	1.418E-02	-1.072E-02	-9.779E-02	2.502E-01	1.151E-01	-1.122E-01	.0	.0
14	1.000E+00 .0	-6.350E+01	2.398E-02	-1.159E-02	-1.093E-01	2.527E-01	1.218E-01	-1.096E-01	.0	.0
15	1.000E+00 .0	-6.720E+01	2.694E-02	-1.185E-02	-1.129E-01	2.510E-01	1.235E-01	-1.083E-01	.0	.0
16	1.000E+00	-8.950E+01	4.338E-02	-1.222E-02	-1.291E-01	2.417E-01	1.294E-01	-9.761E-02	.0	.0

	.0									
17	1.[illegible]E+00	-1.[illegible]E+02	6.[illegible]E-02	-2.[illegible]E-02	-1.[illegible]E-01	2.[illegible]E-01	1.[illegible]E-01	-7.[illegible]E-02	.0	.0
	.0									
18	1.0000E+00	-1.4856E+02	1.1196E-01	-6.9764E-03	-1.7966E-01	1.8648E-01	1.1694E-01	-2.7844E-02	.0	.0
	.0									
19	1.0000E+00	-1.5258E+02	1.1788E-01	-6.4886E-03	-1.8768E-01	1.8045E-01	1.1298E-01	-2.0929E-02	.0	.0
	.0									
20	1.0000E+00	-1.9956E+02	1.8508E-01	8.8756E-03	-1.9756E-01	9.5966E-02	9.2629E-02	5.5378E-02	.0	.0
	.0									
21	1.0000E+00	-2.2438E+02	2.2546E-01	2.1529E-02	-1.9699E-01	1.2922E-02	8.8768E-03	9.0245E-02	.0	.0
	.0									
22	1.0000E+00	-2.4822E+02	2.5286E-01	3.3766E-02	-1.9068E-01	-2.1168E-02	-2.3038E-02	1.0965E-01	.0	.0
	.0									
23	1.0000E+00	-2.8746E+02	3.4398E-01	8.3579E-02	-1.6515E-01	-1.0906E-01	-1.2636E-01	9.6338E-02	.0	.0
	.0									
24	1.0000E+00	-2.9429E+02	3.5758E-01	9.3665E-02	-1.5482E-01	-1.1198E-01	-1.3967E-01	8.5678E-02	.0	.0
	.0									
25	1.0000E+00	-3.1058E+02	3.9198E-01	1.2211E-01	-1.0418E-01	-1.1950E-01	-1.4878E-01	4.4918E-02	.0	.0
	.0									
26	1.0000E+00	-3.4044E+02	4.5633E-01	1.8845E-01	-3.3198E-02	-1.[illegible]E-01	-2.0838E-01	-7.3987E-02	.0	.0
	.0									
27	1.0000E+00	-3.5758E+02	4.9425E-01	2.3371E-01	1.9089E-02	-7.1246E-02	-2.1788E-01	-1.8047E-01	.0	.0
	.0									
28	1.0000E+00	-3.7468E+02	5.3295E-01	2.8241E-01	6.9438E-02	-8.[illegible]E-02	-2.1238E-01	-2.0915E-01	.0	.0
	.0									
29	1.0000E+00	-3.8858E+02	5.6555E-01	3.2447E-01	1.1918E-01	8.0533E-03	-1.9998E-01	-2.3869E-01	.0	.0
	.0									
30	1.0000E+00	-4.0378E+02	6.0729E-01	3.1071E-01	3.4563E-01	2.[illegible]E-01	-1.0718E-02	-3.9867E-01	.0	.0
	.0									
31	1.0000E+00	-4.[illegible]E+02	7.4316E-01	4.8569E-01	4.3528E-01	3.2115E-01	9.1168E-02	-4.0458E-01	.0	.0
	.0									
32	1.0000E+00	-5.0568E+02	8.5918E-01	7.5548E-01	4.6747E-01	5.8999E-01	4.3048E-01	2.6528E-01	.0	.0
	.0									
33	1.0000E+00	-5.4408E+02	9.6667E-01	9.4179E-01	9.2369E-01	9.0268E-01	8.6379E-01	8.1358E-01	.0	.0
	.0									
34	1.0000E+00	-5.6229E+02	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	.0	.0
	.0									

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INPUT MODE SHAPES ROTATION - X

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	.0 .0	.0	1.781E-05	-1.616E-05	-3.229E-05	1.933E-04	4.675E-05	-8.034E-05	.0	.0
2	.0 .0	.0	3.124E-05	-2.833E-05	-5.578E-05	3.342E-04	7.936E-05	-1.352E-04	.0	.0
3	.0 .0	.0	4.104E-05	-3.716E-05	-7.248E-05	4.344E-04	1.018E-04	-1.723E-04	.0	.0
4	.0 .0	.0	5.681E-05	-5.123E-05	-9.819E-05	5.876E-04	1.340E-04	-2.234E-04	.0	.0
5	.0 .0	-4.880E-01	2.005E-05	-6.325E-05	-1.078E-04	6.287E-04	1.592E-04	-2.567E-04	.0	.0
6	.0 .0	-4.880E-01	5.916E-05	-7.892E-05	-1.724E-04	8.488E-04	2.382E-04	-3.561E-04	.0	.0
7	.0 .0	-4.880E-01	7.517E-05	-8.474E-05	-1.970E-04	9.248E-04	2.653E-04	-3.854E-04	.0	.0
8	.0 .0	-4.880E-01	1.012E-04	-9.345E-05	-2.347E-04	1.031E-03	3.011E-04	-4.109E-04	.0	.0
9	.0 .0	-4.880E-01	1.605E-04	-1.097E-04	-3.103E-04	1.195E-03	3.561E-04	-4.294E-04	.0	.0
10	.0 .0	-6.008E-01	2.159E-04	-8.281E-05	-3.953E-04	1.003E-03	4.252E-04	-4.166E-04	.0	.0
11	.0 .0	-6.008E-01	2.399E-04	-8.241E-05	-4.172E-04	9.766E-04	4.238E-04	-3.740E-04	.0	.0
12	.0 .0	-6.008E-01	3.554E-04	-6.853E-05	-4.992E-04	6.576E-04	3.839E-04	-1.281E-04	.0	.0
13	.0 .0	-6.008E-01	4.313E-04	-4.590E-05	-5.289E-04	2.404E-04	3.298E-04	6.336E-05	.0	.0
14	.0 .0	-6.008E-01	4.709E-04	-2.940E-05	-5.361E-04	-4.836E-05	2.933E-04	1.703E-04	.0	.0
15	.0 .0	-6.008E-01	5.025E-04	-1.483E-05	-5.386E-04	-2.977E-04	2.592E-04	2.595E-04	.0	.0
16	.0 .0	-6.008E-01	5.573E-04	2.153E-06	-5.279E-04	-4.390E-04	1.359E-04	4.182E-04	.0	.0
17	.0 .0	-6.008E-01	6.479E-04	3.840E-05	-4.852E-04	-6.766E-04	-9.299E-05	6.568E-04	.0	.0
18	.0	-6.008E-01	7.375E-04	8.867E-05	-4.025E-04	-9.062E-04	-3.524E-04	8.392E-04	.0	.0

	.0									
19	.0	-6.004E-01	8.158E-04	1.452E-04	-2.915E-04	-1.095E-03	-8.249E-04	9.635E-04	.0	.0
	.0									
20	.0	-6.008E-01	9.287E-04	2.483E-04	-9.550E-05	-1.265E-03	-9.440E-04	9.416E-04	.0	.0
	.0									
21	.0	-6.004E-01	1.021E-03	3.772E-04	1.360E-04	-1.300E-03	-1.162E-03	6.944E-04	.0	.0
	.0									
22	.0	-6.008E-01	1.095E-03	5.071E-04	3.656E-04	-1.236E-03	-1.289E-03	3.329E-04	.0	.0
	.0									
23	.0	-6.008E-01	1.205E-03	8.293E-04	8.321E-04	-7.552E-04	-1.24[illegible]E-03	-7.139E-04	.0	.0
	.0									
24	.0	-6.008E-01	1.231E-03	9.445E-04	9.766E-04	-5.302E-04	-1.173E-03	-1.097E-03	.0	.0
	.0									
25	.0	-5.984E-01	1.273E-03	1.155E-03	1.253E-03	-2.147E-05	-9.613E-04	-1.868E-03	.0	.0
	.0									
26	.0	-5.964E-01	1.306E-03	1.511E-03	1.590E-03	8.609E-04	-5.758E-04	-2.983E-03	.0	.0
	.0									
27	.0	-5.964E-01	1.340E-03	1.646E-03	1.811E-03	1.221E-03	-4.459E-05	-2.340E-03	.0	.0
	.0									
28	.0	-5.964E-01	1.366E-03	1.752E-03	1.991E-03	1.526E-03	4.512E-04	-1.690E-03	.0	.0
	.0									
29	.0	-5.964E-01	1.394E-03	1.868E-03	2.198E-03	1.880E-03	1.075E-03	-8.230E-04	.0	.0
	.0									
30	.0	-5.964E-01	1.462E-03	2.165E-03	2.740E-03	2.849E-03	2.913E-03	2.031E-03	.0	.0
	.0									
31	.0	-5.964E-01	1.495E-03	2.312E-03	3.021E-03	3.[illegible]E-03	3.971E-03	3.817E-03	.0	.0
	.0									
32	.0	-5.964E-01	1.534E-03	2.505E-03	3.378E-03	4.060E-03	5.434E-03	6.557E-03	.0	.0
	.0									
33	.0	-5.964E-01	1.553E-03	2.603E-03	3.556E-03	4.428E-03	6.237E-03	8.247E-03	.0	.0
	.0									
34	.0	-5.964E-01	1.555E-03	2.626E-03	3.577E-03	4.508E-03	6.401E-03	8.836E-03	.0	.0
	.0									

INPUT MODE SHAPES ROTATION - Y

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	.0 .0	1.000E+00	9.212E-05	7.837E-05	-1.278E-05	-5.438E-05	-4.739E-06	1.326E-05	.0	.0
2	.0 .0	1.000E+00	9.046E-05	7.715E-05	-8.669E-06	-5.449E-05	-1.186E-05	2.274E-05	.0	.0
3	.0 .0	1.000E+00	8.929E-05	2.624E-05	-5.639E-06	-5.384E-05	-1.667E-05	2.893E-05	.0	.0
4	.0 .0	1.000E+00	8.736E-05	2.473E-05	-1.181E-06	-5.264E-05	-2.457E-05	3.905E-05	.0	.0
5	.0 .0	8.728E-01	1.046E-04	-7.105E-06	-4.829E-05	2.653E-04	4.083E-05	-7.206E-05	.0	.0
6	.0 .0	8.728E-01	1.013E-04	-5.199E-05	-1.911E-05	5.188E-04	-2.974E-05	9.778E-06	.0	.0
7	.0 .0	8.728E-01	9.947E-05	-7.629E-05	-3.269E-06	6.559E-04	-6.806E-05	5.428E-05	.0	.0
8	.0 .0	8.728E-01	9.633E-05	-1.165E-04	2.269E-05	8.814E-04	-1.2 6E-04	1.157E-04	.0	.0
9	.0 .0	8.728E-01	8.904E-05	-2.111E-04	8.360E-05	1.401E-03	-2.634E-04	2.630E-04	.0	.0
10	.0 .0	7.994E-01	1.160E-04	-3.418E-04	9.858E-05	2.200E-03	-3.719E-04	3.906E-04	.0	.0
11	.0 .0	7.994E-01	1.187E-04	-3.841E-04	1.176E-04	2.431E-03	-4.193E-04	4.392E-04	.0	.0
12	.0 .0	7.994E-01	1.317E-04	-5.938E-04	2.112E-04	3.592E-03	-6.371E-04	6.627E-04	.0	.0
13	.0 .0	7.994E-01	1.412E-04	-7.469E-04	2.795E-04	4.370E-03	-7.961E-04	7.912E-04	.0	.0
14	.0 .0	7.994E-01	1.465E-04	-8.316E-04	3.161E-04	4.821E-03	-8.767E-04	8.802E-04	.0	.0
15	.0 .0	7.994E-01	1.509E-04	-9.003E-04	3.448E-04	5.177E-03	-9.342E-04	9.052E-04	.0	.0
16	.0 .0	7.994E-01	1.591E-04	-9.957E-04	3.852E-04	5.057E-03	-8.908E-04	8.526E-04	.0	.0
17	.0 .0	7.994E-01	1.735E-04	-1.165E-03	4.600E-04	4.810E-03	-8.174E-04	7.613E-04	.0	.0
18	.0 .0	7.994E-01	1.901E-04	-1.358E-03	5.446E-04	4.529E-03	-7.342E-04	6.582E-04	.0	.0

19	.0 .0	7.994E-01	2.073E-04	-1.550E-03	6.236E-04	4.199E-03	-6.292E-04	5.429E-04	.0	.0
20	.0 .0	7.994E-01	2.347E-04	-1.852E-03	7.445E-04	3.632E-03	-4.467E-04	3.377E-04	.0	.0
21	.0 .0	7.994E-01	2.646E-04	-2.180E-03	8.762E-04	3.013E-03	-2.482E-04	1.147E-04	.0	.0
22	.0 .0	7.994E-01	2.935E-04	-2.489E-03	9.979E-04	2.392E-03	-6.550E-05	-8.674E-05	.0	.0
23	.0 .0	7.994E-01	3.568E-04	-3.153E-03	1.251E-03	1.094E-03	1.345E-04	-5.039E-04	.0	.0
24	.0 .0	7.994E-01	3.775E-04	-3.371E-03	1.334E-03	5.491E-04	4.654E-04	-6.404E-04	.0	.0
25	.0 .0	8.026E-01	4.118E-04	-3.785E-03	1.478E-03	-3.414E-04	6.859E-04	-8.712E-04	.0	.0
26	.0 .0	8.026E-01	4.686E-04	-4.343E-03	1.679E-03	-1.575E-03	9.617E-04	-1.179E-03	.0	.0
27	.0 .0	8.026E-01	4.698E-04	-4.361E-03	1.690E-03	-1.611E-03	9.636E-04	-1.374E-03	.0	.0
28	.0 .0	8.026E-01	4.7[illegible]E-04	-4.377E-03	1.699E-03	-1.640E-03	9.713E-04	-1.516E-03	.0	.0
29	.0 .0	8.026E-01	4.707E-04	-4.388E-03	1.708E-03	-1.661E-03	9.732E-04	-1.719E-03	.0	.0
30	.0 .0	8.026E-01	4.740E-04	-4.422E-03	1.738E-03	-1.736E-03	9.465E-04	-2.439E-03	.0	.0
31	.0 .0	8.026E-01	4.762E-04	-4.435E-03	1.759E-03	-1.763E-03	9.[illegible]7E-04	-2.854E-03	.0	.0
32	.0 .0	8.026E-01	4.815E-04	-4.465E-03	1.806E-03	-1.826E-03	9.274E-04	-3.820E-03	.0	.0
33	.0 .0	8.026E-01	4.852E-04	-4.487E-03	1.843E-03	-1.869E-03	9.335E-04	-4.583E-03	.0	.0
34	.0 .0	8.026E-01	4.885E-04	-4.506E-03	1.876E-03	-1.907E-03	9.391E-04	-5.272E-03	.0	.0

INPUT POINT LOCATIONS (REFERENCE AXIS)

ROW	X	Y	Z	THETA-X	THETA-Y	THETA-Z
1	1.154E+03	5.171E+01	1.433F+02	7.000E+00	2.000E+00	.0
2	1.154E+03	6.352E+01	1.448E+02	7.000E+00	2.000E+00	.0
3	1.154F+03	9.131F+01	1.482F+02	7.000E+00	2.000E+00	.0
4	1.155E+03	1.275E+02	1.527E+02	7.000E+00	2.000E+00	.0
5	1.162E+03	1.404F+02	1.540E+02	7.000E+00	2.000E+00	.0
6	1.192E+03	1.923E+02	1.593E+02	7.000E+00	2.000E+00	.0
7	1.201E+03	2.099E+02	1.611E+02	7.000E+00	2.000E+00	.0
8	1.217E+03	2.372E+02	1.639E+02	7.000E+00	2.000E+00	.0
9	1.247E+03	2.913E+02	1.695E+02	7.000E+00	2.000E+00	.0
10	1.281E+03	3.390E+02	1.742E+02	7.000E+00	2.000E+00	.0
11	1.286E+03	3.454E+02	1.748E+02	7.000E+00	2.000E+00	.0
12	1.334E+03	4.078E+02	1.808E+02	7.000E+00	2.000E+00	.0
13	1.362E+03	4.445E+02	1.844E+02	7.000E+00	2.000E+00	.0
14	1.375E+03	4.617E+02	1.860E+02	7.000E+00	2.000E+00	.0
15	1.379E+03	4.665E+02	1.865E+02	7.000E+00	2.000E+00	.0
16	1.397E+03	4.913E+02	1.889E+02	7.000E+00	2.000E+00	.0
17	1.422E+03	5.244E+02	1.921E+02	7.000E+00	2.000E+00	.0
18	1.460E+03	5.738E+02	1.968E+02	7.000E+00	2.000E+00	.0

19	1.464E+03	5.796E+02	1.934E+02	3.000E+00	2.000E+00	.0
20	1.511E+03	6.409E+02	2.039E+02	3.000E+00	2.000E+00	.0
21	1.534E+03	6.739E+02	2.084E+02	3.000E+00	2.000E+00	.0
22	1.552E+03	6.993E+02	2.084E+02	3.000E+00	2.000E+00	.0
23	1.600E+03	7.574E+02	2.145E+02	3.000E+00	2.000E+00	.0
24	1.607E+03	7.652E+02	2.159E+02	3.000E+00	2.000E+00	.0
25	1.623E+03	7.881E+02	2.174E+02	3.000E+00	2.000E+00	.0
26	1.653E+03	8.278E+02	2.213E+02	3.000E+00	2.000E+00	.0
27	1.670E+03	8.506E+02	2.235E+02	3.000E+00	2.000E+00	.0
28	1.687E+03	8.734E+02	2.257E+02	3.000E+00	2.000E+00	.0
29	1.701E+03	8.923E+02	2.275E+02	3.000E+00	2.000E+00	.0
30	1.757E+03	9.657E+02	2.346E+02	3.000E+00	2.000E+00	.0
31	1.776E+03	9.905E+02	2.370E+02	3.000E+00	2.000E+00	.0
32	1.919E+03	1.048E+03	2.426E+02	3.000E+00	2.000E+00	.0
33	1.863E+03	1.107E+03	2.489E+02	3.000E+00	2.000E+00	.0
34	1.876E+03	1.124E+03	2.499E+02	3.000E+00	2.000E+00	.0

INPUT POINT LOCATIONS (LOCAL AXIS)

ROW	X	Y	Z	THETA-X	THETA-Y	THETA-Z
1	3.750E+02	5.210E+01	-1.378E-06			
2	3.750E+02	6.460E+01	-1.420E-06			
3	3.750E+02	9.200E+01	-1.521E-06			
4	3.750E+02	1.285E+02	-1.659E-06			
5	3.827E+02	1.415E+02	-1.724E-06			
6	4.125E+02	1.933E+02	-2.006E-06			
7	4.214E+02	2.115E+02	-2.100E-06			
8	4.370E+02	2.390E+02	-2.249E-06			
9	4.670E+02	2.935E+02	-2.542E-06			
10	5.011E+02	3.415E+02	-2.829E-06			
11	5.060E+02	3.480E+02	-2.862E-06			
12	5.530E+02	4.109E+02	-3.229E-06			
13	5.810E+02	4.478E+02	-3.461E-06			
14	5.940E+02	4.65[illegible]+02	-3.565E-06			
15	5.977E+02	4.700E+02	-3.[illegible]4E-06			
16	6.160E+02	4.950E+02	-3.743E-06			
17	6.415E+02	5.289E+02	-3.942E-06			
18	6.750E+02	5.781E+02	-4.243E-06			
19	6.830E+02	5.840E+02	-4.277E-06			
20	7.300E+02	6.457E+02	-4.649E-06			
21	7.548E+02	6.790E+02	-4.848E-06			
22	7.707E+02	6.995E+02	-4.973E-06			
23	8.180E+02	7.631E+02	-5.353E-06			
24	8.247E+02	7.720E+02	-5.406E-06			

25	8.410E+02	7.940E+02	-5.538E-06
26	8.709E+02	8.340E+02	-5.777E-06
27	8.880E+02	8.570E+02	-5.915E-06
28	9.051E+02	8.800E+02	-6.052E-06
29	9.140E+02	8.990E+02	-6.165E-06
30	9.742E+02	9.730E+02	-6.607E-06
31	9.928E+02	9.979E+02	-6.756E-06
32	1.036E+03	1.056E+03	-7.104E-06
33	1.080E+03	1.115E+03	-7.456E-06
34	1.093E+03	1.132E+03	-7.560E-06

```
($SURFACE      2     INBD. AIL.                                                    )
       SURFACE NUMBER (    2) MNEMONIC IDENTIFICATION IS (INBD. AIL.)

($TRANSFORM                                                                      )
                      TRANSLATION                    ROTATION (DEGREES)
                 X          Y          Z         PHIX       PHIY       PHIZ
           7.792E+02     .0         1.501E+02   7.000E+00   2.000E+00     .0

            ---------- ROTATION ----------          TRANSLATION

           9.993908E-01    .0          -3.489950E-02   7.791900E+02
           4.253179E-03   9.925462E-01   1.217951E-01    .0
           3.463936E-02  -1.218693E-01   9.919415E-01   1.500900E+02

($C          NODES ON HINGE LINE                                                 )
($NODES      FROM       CARD      LOCAL          2                             )
       NODE COORDINATES ARE INPUT FROM (CART      ) IN (LOCAL     ) AXIS FRAME IN THE (METRIC    ) UNIT SYSTEM.
       NUMBER OF NODES TO BE READ IS (    2)

   7.0000E+02  3.5000E+02   .0          -.0          -.0          -.0
   7.0000E+02  5.1500E+02   .0          -.0          -.0          -.0
($C          PARENT SURFACE IS MAIN WING SURFACE                                 )
($NODES      FROM          1                                                     )
($RIGID         9          1                                                     )
($HINGE      700.       350.       700.       515.       1.0                    )
($SA                       1     1    1                                         )
       SA(I) SELECTED FREEDOMS ARE  0 0 1 1 1 0

($MOTIONAXIS    2    0                                                           )
       M O T I O N   A X I S   SCHEME

       NUMBER OF DEFINITION POINTS =     2
       INDICATOR FOR ROTATION  Rx  ORIENTATION (    0)
                 EQUAL 0, FREESTREAM
                 NOT EQUAL 0, PERPENDICULAR TO LOCAL STRAIGHT LINE MOTION AXIS

           X-LOC        Y-LOC        SLOPE

     1    7.000E+02   3.500E+02    .0
     2    7.000E+02   5.150E+02    .0
($PRINT     SA                                                                   )
       PRINT OPTION IS     1 (SA        )(          )(          )

($PRINT     LOCATIONS                                                            )
       PRINT OPTION IS     3 (LC        )(          )(          )

($PRINT     NODE                                                                 )
       PRINT OPTION IS     7 (ND        )(          )(          )

($END                                                                            )
```

8.

```
********************************  TITLE  ********************************
TITLE     HIGH ASPECT RATIO WING WITH 11 MODAL FREEDOMS

          INPUT MODE SHAPES  TRANSLATION - X

 ROW        1MODE        2MODE        3MODE        4MODE        5MODE        6MODE        7MODE        8MODE        9MODE       10MODE
           11MODE

   1    .0           .0           .0           .0           .0           .0           .0           .0           .0           .0
        .0

   2    .0           .0           .0           .0           .0           .0           .0           .0           .0           .0
        .0

          INPUT MODE SHAPES  TRANSLATION - Y

 ROW        1MODE        2MODE        3MODE        4MODE        5MODE        6MODE        7MODE        8MODE        9MODE       10MODE
           11MODE

   1    .0           .0           .0           .0           .0           .0           .0           .0           .0           .0
        .0

   2    .0           .0           .0           .0           .0           .0           .0           .0           .0           .0
        .0

          INPUT MODE SHAPES  TRANSLATION - Z

 ROW        1MODE        2MODE        3MODE        4MODE        5MODE        6MODE        7MODE        8MODE        9MODE       10MODE
           11MODE

   1    1.000E+00   -1.683E+02   -1.098E-02    1.025E-01   -1.353E-01   -4.134E-01    2.322E-01   -2.317E-01    .0           .0
        .0

   2    1.000E+00   -1.695E+02    7.546E-02    4.908E-02   -1.862E-01   -7.645E-02    1.773E-01   -1.043E-01    .0           .0
        .0

          INPUT MODE SHAPES  ROTATION - X

 ROW        1MODE        2MODE        3MODE        4MODE        5MODE        6MODE        7MODE        8MODE        9MODE       10MODE
           11MODE

   1    .0           1.941E-02    3.777E-04   -1.663E-04   -3.727E-04    1.143E-03    1.345E-04    1.469E-04    .0           .0
        .0

   2    .0           1.884E-01    8.070E-04   -8.047E-04   -1.256E-04    2.726E-03   -3.994E-04    9.134E-04    .0           .0
        .0
```

INPUT MODE SHAPES ROTATION - Y

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	-.0 -.0	9.762E-01	-1.023E-04	-7.924E-34	6.136E-04	4.517E-03	-1.071E-03	8.587E-04	1.000E+00	-.0
2	-.0 -.0	9.996E-01	-2.500E-04	-7.465E-34	6.112E-04	4.632E-03	-8.107E-04	3.514E-04	1.000E+00	-.0

INPUT MODE SHAPES ROTATION - Z

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	.0 .0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.0 .0	.0	.0	.0	.0	.0	.0	.0	.0	.0

INPUT POINT LOCATIONS (REFERENCE AXIS)

ROW	X	Y	Z	THETA-X	THETA-Y	THETA-Z
1	1.480E+03	5.474E+02	1.683E+02	7.000E+01	2.000E+00	.0
2	1.481E+03	5.112E+02	1.884E+02	3.000E+00	2.000E+00	.0

INPUT POINT LOCATIONS (LOCAL AXIS 1)

ROW	X	Y	Z	THETA-X	THETA-Y	THETA-Z
1	7.000E+02	3.500E+02	.0			
2	7.000E+02	5.150E+02	.0			

SA ARRAY (FUNCTIONAL COEFFICIENTS)

ROW		
1	202	POINTER TO LAST ELEMENT
2	MOTIONAXIS	METHOD OF INTERPOLATION
3	190	POINTER TO TRANSFORMATION
4	11	MCOLS, TOTAL NUMBER OF MODES
5	1	MCOL1, MODES 1 THRU MCOL1 WILL BE ZEROS
6	11	MCOLN, MODES MCOLN+1 THRU MCOLS WILL BE ZEROS

7	2.000E+00	2.000E+00	7.000E+02	7.000E+02						
11	3.500E+02	5.150E+02	.0	.0	.0	1.650E+02	.0	.0	7.000E+02	.0
21	.0	.0	.0	1.657E+32	1.090E+00	1.000E+00	-1.683E+02	-1.695E+02	-1.098E-02	7.546E-02
31	1.025E-01	4.908E-02	-1.353E-01	-1.862E-01	-4.134E-01	-7.645E-02	2.322E-01	1.773E-01	-2.317E-01	-1.043E-01

41	.0	.0	.0	.0	.0	.0	.0	.0	1.941E-02	1.884E-03
51	3.773E-04	6.070E-04	-1.663E-04	-8.047E-04	-3.727E-04	-1.256E-04	1.143E-03	2.226E-03	1.345E-04	-3.996E-04
61	1.469E-04	9.134E-04	.0	.0	.0	.0	.0	.0	.0	.0
71	9.762E-01	9.996E-01	-1.021E-04	-2.590E-04	-7.924E-04	-7.485E-04	6.136E-04	6.312E-04	4.517E-03	4.632E-03
81	-1.071E-03	-8.107E-04	8.587E-04	3.514E-04	1.000E+00	1.000E+00	.0	.0	.0	.0
91	2.153E-17	2.153E-17	-7.439E-03	-7.439E-03	5.239E-04	5.239E-04	-3.237E-04	-3.237E-04	-3.084E-04	-3.084E-04
101	2.042E-03	2.042E-03	-3.325E-04	-3.325E-04	7.724E-04	7.724E-04	.0	.0	.0	.0
111	.0	.0	.0	.0	-1.062E-04	-1.062E-04	1.390E-06	1.390E-06	-3.869E-06	-3.869E-06
121	1.498E-06	1.498E-06	6.562E-06	6.562E-06	-5.236E-06	-5.236E-06	4.645E-06	4.645E-06	.0	.0
131	.0	.0	.0	.0	.0	.0	1.417E-04	1.417E-04	-8.952E-07	-8.952E-07
141	2.779E-07	2.779E-07	1.068E-07	1.068E-07	6.916E-07	6.916E-07	1.578E-06	1.578E-06	-3.075E-06	-3.075E-06
151	.0	.0	.0	.0	.0	.0	*****	*****	*****	*****
161	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
171	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
181	*****	*****	*****	*****	*****	*****	*****	*****	*****	9.994E-01
191	4.253E-03	3.464E-02	.0	9.925E-01	-1.219E-01	-3.490E-02	1.218E-01	9.919E-01	7.792E+02	.0
201	1.901E+02									

202 NOTIONARIS METHOD OF INTERPOLATION LAST WORD

```
($SURFACE      3     I.A. TAB                                                    )
       SURFACE NUMBER (    3) MNEMONIC IDENTIFICATION IS ('I.A. TAB  )

($TRANSFORM                                                                     )
                      TRANSLATION                    ROTATION (DEGREES)
                 X          Y          Z          PHIX       PHIY       PHIZ
           7.7919E+02    .0        1.501E+02   7.000E+00   2.000E+00    .0

            ------.------ ROTATION ----------          TRANSLATION

           9.9939508E-01    .0          -3.4899507E-02   7.7919000E+02
           4.2511790E-03   9.9254642E-01   1.2179511E-01    .0
           3.4639368E-02  -1.2186493E-01   9.9194150E-01   1.5009000E+02

($C            NODES ON HINGE LINE                                              )
($NODES        FROM      CARDS     LOCAL          2                           )
       NODE COORDINATES ARE INPUT FROM ('CARDS     ) IN ('LOCAL     ) AXIS FRAME IN THE ('METRIC    ) UNIT SYSTEM.
       NUMBER OF NODES TO BE READ IS (    21

   7.5050E+02  4.4500E+02   .0          -.0          -.0          -.0
   7.5050E+02  5.1500E+02   .0          -.0          -.0          -.0
($C            PARENT SURFACE IS INBOARD AIL.                                   )
($NODES        FROM          2                                                  )
($RIGID          11    1                                                        )
($HINGE        750.5     445.0     750.5     515.      1.0                     )
($SA                       1    1    1
       SA(1) SELECTED FREEDOMS ARE  0 0 1 1 1 0

($MOTIONAXIS    2    0                                                          )
       M O T I O N   A X I S   SCHEME

       NUMBER OF DEFINITION POINTS =     2
       INDICATOR FOR ROTATION  RX  ORIENTATION (    0)
                 EQUAL 0, FREESTREAM
                 NOT EQUAL 0, PERPENDICULAR TO LOCAL STRAIGHT LINE MOTION AXIS

            X-LOC       Y-LOC       SLOPE

      1    7.505E+02   4.450E+02    .0
      2    7.505E+02   5.150E+02    .0
($PRINT      LOCATIONS                                                          )
       PRINT OPTION IS     2 (LC        )(          )(          )

($PRINT      MODE                                                               )
       PRINT OPTION IS     6 (MO        )(          )(          )

($END                                                                           )
```

1

********** TITLE **********

TITLE HIGH ASPECT RATIO WING WITH 11 MODAL FREEDOMS

INPUT MODE SHAPES TRANSLATION - X

ROW	1MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
	11MODE									
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	.0									
2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	.0									

INPUT MODE SHAPES TRANSLATION - Y

ROW	1MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
	11MODE									
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	.0									
2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	.0									

INPUT MODE SHAPES TRANSLATION - Z

ROW	1MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
	11MODE									
1	1.000E+00	-2.190E+02	4.625E-02	1.104E-01	-1.961E-01	-4.508E-01	2.471E-01	-1.870E-01	-5.050E+01	.0
	.0									
2	1.000E+00	-2.200E+02	6.809E-02	8.677E-02	-2.181E-01	-3.103E-01	2.183E-01	-1.220E-01	-5.050E+01	.0
	.0									

INPUT MODE SHAPES ROTATION - X

ROW	1MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
	11MODE									
1	.0	2.164E-03	5.549E-04	-5.479E-04	-2.358E-04	1.732E-03	-2.526E-04	7.435E-04	.0	.0
	.0									
2	.0	-5.272E-03	6.522E-04	-8.188E-04	-1.509E-04	2.191E-03	-4.791E-04	1.069E-03	.0	.0
	.0									

INPUT MODE SHAPES ROTATION - Y

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	.0 1.000E+00	9.897E-01	-1.873E-04	-7.460E-04	6.238E-04	4.583E-03	-9.212E-04	5.666E-04	1.000E+00	.0
2	.0 1.000E+00	9.996E-01	-2.500E-04	-7.465E-04	6.912E-04	4.632E-03	-8.107E-04	3.514E-04	1.000E+00	.0

INPUT MODE SHAPES ROTATION - Z

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	.0 .0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.0 .0	.0	.0	.0	.0	.0	.0	.0	.0	.0

INPUT POINT LOCATIONS (REFERENCE AXIS)

ROW	X	Y	Z	THETA-X	THETA-Y	THETA-Z
1	1.531E+03	4.417E+02	1.781E+02	7.000E+00	2.000E+00	.0
2	1.531E+03	5.112E+02	1.866E+02	7.000E+00	2.000E+00	.0

INPUT POINT LOCATIONS (LOCAL AXIS)

ROW	X	Y	Z	THETA-X	THETA-Y	THETA-Z
1	7.505E+02	4.450E+02	.0			
2	7.505E+02	5.150E+02	.0			

```
($SURFACE      4     OUTBD. AIL                                                    )
       SURFACE NUMBER (    4) MNEMONIC IDENTIFICATION IS (OUTBD. AIL)

($TRANSFORM                                                                       )
                     TRANSLATION                      ROTATION (DEGREES)
                X            Y            Z          PHIX         PHIY        PHIZ
          7.792E+02     .0          1.501E+02    7.000E+00    2.000E+00     .0

           ---------- ROTATION ----------          TRANSLATION

          9.993908E-01    .0          -3.489950E-02    7.791900E+02
          4.253179E-03   9.925462E-01   1.217951E-01     .0
          3.463936E-02  -1.218693E-01   9.919415E-01    1.500900E+02

($C         NODES ON HINGE LINE                                                   )
($NODES     FROM      CARD      LOCAL         4                                   )
       NODE COORDINATES ARE INPUT FROM (CARD      ) IN (LOCAL     ) AXIS FRAME IN THE (METRIC    ) UNIT SYSTEM.
       NUMBER OF NODES TO BE READ IS (     4)

   9.650DE+02  8.500DE+02   .0          -.0          -.0          -.0
   1.027JE+03  9.500DE+02   .0          -.0          -.0          -.0
   1.089SE+03  1.050DE+03   .0          -.0          -.0          -.0
   1.130DE+03  1.115DE+03   .0          -.0          -.0          -.0
($C         PARENT SURFACE IS MAIN WING SURFACE                                   )
($NODES     FROM          1                                                       )
($RIGID        ID    1                                                          )
($HINGE     965.0     850.0     1130.0    1115.0    1.                          )
($SA                1     1     1                                               )
       SA(1) SELECTED FREEDOMS ARE  0 0 1 1 1 0

($MOTIONAXIS    2    0                                                            )
       M O T I O N   A X I S   SCHEME

       NUMBER OF DEFINITION POINTS =      2
       INDICATOR FOR ROTATION AX ORIENTATION (    0)
                 EQUAL 0, FREESTREAM
                 NOT EQUAL 0, PERPENDICULAR TO LOCAL STRAIGHT LINE MOTION AXIS

           X-LOC        Y-LOC        SLOPE

      1    9.65DE+02   8.500E+02    .0
      2    1.130E+03   1.115E+03    .0
($PRINT     LOCATION                                                              )
       PRINT OPTION IS     2 (LC        )(          )(          )

($PRINT     MODE                                                                  )
       PRINT OPTION IS     6 (MC        )(          )(          )

($END                                                                             )
```

********** TITLE **********

TITLE HIGH ASPECT RATIO WING WITH 11 MODAL FREEDOMS

INPUT MODE SHAPES TRANSLATION - X

ROW	1MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE	11MODE
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

INPUT MODE SHAPES TRANSLATION - Y

ROW	1MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	PROW	9MODE	10MODE	11MODE
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

INPUT MODE SHAPES TRANSLATION - Z

ROW	1MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE	11MODE
1	1.000E+00	-4.345E+02	5.179E-01	5.925E-01	-1.897E-02	9.622E-02	-2.689E-01	-1.183E-01	.0	.0	.0
2	1.000E+00	-4.967E+02	6.898E-01	7.892E-01	2.845E-01	3.819E-01	-2.719E-02	-1.629E-02	.0	1.281E-04	.0
3	1.000E+00	-5.591E+02	8.719E-01	1.032E+00	6.748E-01	7.866E-01	5.378E-01	6.337E-01	.0	2.563E-04	.0
4	1.000E+00	-5.994E+02	9.930E-01	1.203E+00	9.534E-01	1.113E+00	1.014E+00	1.242E+00	.0	-9.095E-13	.0

INPUT MODE SHAPES ROTATION - X

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	.0 .0	1.348E-04	1.387E-04	-1.199E-03	2.676E-03	4.216E-04	1.180E-03	-1.566E-03	.0	5.286E-01
2	.0 .0	1.268E-04	1.484E-03	-8.360E-04	3.376E-03	1.456E-03	3.262E-03	1.265E-03	.0	5.286E-01
3	.0 .0	1.169E-04	1.522E-03	-6.165E-04	3.841E-03	2.293E-03	5.174E-03	3.583E-03	.0	5.286E-01
4	.0 .0	-3.230E-05	1.541E-03	-5.634E-04	3.992E-03	2.494E-03	5.708E-03	3.978E-03	.0	5.286E-01

INPUT MODE SHAPES ROTATION - Y

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	-.0 -.0	9.999E-01	-4.447E-04	-4.615E-03	1.335E-04	-2.373E-03	3.361E-04	-8.568E-04	-.0	8.489E-01
2	-.0 -.0	9.999E-01	-4.966E-04	-4.895E-03	-2.812E-04	-3.259E-03	-1.248E-03	-4.181E-03	-.0	8.489E-01
3	-.0 -.0	9.999E-01	-5.282E-04	-5.108E-03	-5.901E-04	-3.983E-03	-2.681E-03	-7.585E-03	-.0	8.489E-01
4	.0 .0	9.999E-01	-5.304E-04	-5.185E-03	-6.143E-04	-4.211E-03	-3.049E-03	-9.489E-03	.0	8.489E-01

INPUT MODE SHAPES ROTATION - Z

ROW	1MODE 11MODE	2MODE	3MODE	4MODE	5MODE	6MODE	7MODE	8MODE	9MODE	10MODE
1	.0 .0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.0 .0	.0	.0	.0	.0	.0	.0	.0	.0	.0
3	.0 .0	.0	.0	.0	.0	.0	.0	.0	.0	.0
4	.0 .0	.0	.0	.0	.0	.0	.0	.0	.0	.0

INPUT POINT LOCATIONS (REFERENCE AXIS)

POW	X	Y	Z	THETA-X	THETA-Y	THETA-Z
1	1.943E+03	8.437E+02	2.199E+02	7.000E+00	2.000E+00	.0
2	1.810E+03	9.429E+02	2.299E+02	7.000E+00	2.000E+00	.0
3	1.673E+03	1.042E+03	2.400E+02	7.000E+00	2.000E+00	.0
4	1.913E+03	1.107E+03	2.465E+02	7.000E+00	2.000E+00	.0

INPUT POINT LOCATIONS (LOCAL AXIS 1

POW	X	Y	Z	THETA-X	THETA-Y	THETA-Z
1	9.650E+02	8.500E+02	.0			
2	1.927E+03	9.500E+02	.0			
3	1.040E+03	1.050E+03	.0			
4	1.130E+03	1.115E+03	.0			

```
(MOTAPE    MODEOUT                                                              )

     TAPE NAME (MODEOUT) WHERE INTERPOLATED MODAL OUTPUT IS WRITTEN.

:&MODE     747 WING                                                             )
(AEROT     779.19    0.0       150.09                                         )

     AERODYNAMIC SURFACE TRANSFORMATION
     ORIGIN                    OFF-SET
        X =   7.792E+02          X =   -.0
        Y =    .0                Y =   -.0
        Z =   1.501E+02

(OUTLO     READ FROM CARD      LOCAL        36     3                           )

     OUTPUT LOCATIONS ARE INPUT FROM (CARD      ) IN (LOCAL     ) AXIS FRAME.
     NUMBER OF OUTPUT POINTS =   36
     INDICATOR FOR GENERATING SLOPES =    3
     INDICATOR FOR GAMMA (NORMAL ORIENTATIONS) =    0


 NO.      X          Y          Z    ISURF

  1 1.578E+02 9.690E+01  .0          1
  2 3.140E+02 9.690E+01  .0          1
  3 5.343E+02 9.690E+01  .0          1
  4 6.651E+02 9.690E+01  .0          1
  5 3.186E+02 2.882E+02  .0          1
  6 4.614E+02 2.882E+02  .0          1
  7 6.238E+02 2.882E+02  .0          1
  8 7.298E+02 2.882E+02  .0          1
  9 4.728E+02 4.716E+02  .0          1
 10 5.836E+02 4.716E+02  .0          1
 11 7.096E+02 4.716E+02  .0          2
 12 7.918E+02 4.716E+02  .0          9
 13 4.201E+02 6.421E+02  .0          1
 14 7.110E+02 6.421E+02  .0          1
 15 8.143E+02 6.421E+02  .0          1
 16 8.818E+02 6.421E+02  .0          1
 17 7.535E+02 7.951E+02  .0          1
 18 8.295E+02 7.951E+02  .0          1
 19 9.159E+02 7.951E+02  .0          1
 20 9.724E+02 7.951E+02  .0          1
 21 8.613E+02 9.265E+02  .0          1
 22 9.260E+02 9.265E+02  .0          1
 23 1.001E+03 9.265E+02  .0          1
 24 1.050E+03 9.265E+02  .0          4
 25 9.462E+02 1.032E+03  .0          1
 26 1.004E+03 1.032E+03  .0          1
 27 1.078E+03 1.052E+03  .0          1
 28 1.112E+03 1.032E+03  .0          4
 29 1.008E+03 1.110E+03  .0          1
 30 1.061E+03 1.113E+03  .0          1
 31 1.120E+03 1.110E+03  .0          1
 32 1.158E+03 1.117E+03  .0          4
```

```
33 1.0479E+03 1.1594E+03  .0          1
34 1.0959E+03 1.1588E+03  .0          1
35 1.1508E+03 1.1588E+03  .0          1
36 1.1868E+03 1.1587E+03  .0          1
(PRINT       MOM                                                          1
      PRINT OPTION IS     0 (MUDE      01          01          0

(END                                                                      0
```

OUTPUT POINT LOCATIONS ARE SHIFTED LOCAL COORDINATES

ROW	X	Y	Z	DISPLACEMENT Z						
1	1.578E+02	9.690E+01	.0	1.000E+00 2.555E-02	3.752E+02 .0	-3.836E-02 .0	2.889E-02 .0	2.792E-02	-1.265E-01	-2.003E-02
2	3.340E+02	9.690E+01	.0	1.000E+00 1.659E-02	1.973E+02 .0	-5.326E-02 .0	2.279E-02 .0	2.741E-02	-1.028E-01	-1.515E-02
3	5.343E+02	9.690E+01	.0	1.000E+00 1.675E-02	8.886E+00 .0	-7.202E-02 .0	2.134E-02 .0	3.106E-02	-1.237E-01	-1.491E-02
4	6.651E+02	9.690E+01	.0	1.000E+00 -6.037E-02	-1.368E+02 .0	-7.435E-02 .0	3.799E-02 .0	1.405E-04	-1.948E-01	4.713E-02
5	3.186E+02	2.882E+02	.0	1.000E+00 -1.771E-02	2.110E+02 .0	-3.753E-02 .0	-5.600E-04 .0	8.644E-03	1.041E-01	1.496E-03
6	4.614E+02	2.882E+02	.0	1.000E+00 -5.739E-02	6.902E+01 .0	-4.122E-02 .0	4.244E-03 .0	-1.058E-02	8.601E-02	3.563E-02
7	6.238E+02	2.882E+02	.0	1.000E+00 -1.673E-01	-8.532E+01 .0	-3.879E-02 .0	5.736E-02 .0	-4.657E-02	-1.965E-01	1.419E-01
8	7.298E+02	2.882E+02	.0	1.000E+00 -2.543E-01	-1.975E+02 .0	-3.076E-02 .0	1.251F-01 .0	-1.245E-01	-5.628E-01	2.431E-01
9	4.728E+02	4.716E+02	.0	1.000E+00 -4.589E-02	5.644E+01 .0	9.930E-03 .0	-6.517E-02 .0	-5.352E-02	5.887E-01	3.480E-02
10	5.836E+02	4.716E+02	.0	1.000E+00 -9.946E-02	-5.324E+01 .0	2.532E-02 .0	-2.154E-02 .0	-1.051E-01	3.107E-01	1.110E-01
11	7.094E+02	4.716E+02	.0	1.000E+00 -1.425E-01	-1.789E+02 -9.697E+00	5.475E-02 .0	7.041E-02 .0	-1.788E-01	-2.092E-01	2.002E-01
12	7.918E+02	4.716E+02	.0	1.000E+00 -1.823E-01	-2.604E+02 9.180E+01	7.211E-02 .0	1.329E-01 -4.190E+01	-2.303E-01	-5.875E-01	2.725E-01
13	6.201E+02	6.421E+02	.0	1.000E+00 2.413E-02	-8.963E+01 .0	1.436E-01 .0	-1.535E-01 .0	-1.237E-01	4.810E-01	6.265E-02
14	7.110E+02	6.421E+02	.0	1.000E+00 4.588E-02	-1.805E+02 .0	1.749E-01 .0	-1.884E-02 .0	-1.860E-01	1.311E-01	6.007E-02
15	8.143E+02	6.421E+02	.0	1.000E+00 8.959E-02	-2.838E+02 .0	2.129E-01 .0	1.813E-01 .0	-2.590E-01	-1.945E-01	1.559E-02
16	8.818E+02	6.421E+02	.0	1.000E+00 1.326E-01	-3.912E+02 .0	2.378E-01 .0	3.6 6E-01 .0	-3.128E-01	-3.044E-01	-5.281E-02
17	7.535E+02	7.951E+02	.0	1.000E+00 7.811E-02	-2.229E+02 .0	3.521E-01 .0	-1.363E-01 .0	-7.252E-02	5.456E-03	-9.473E-02

18	6.295E+02	7.951E+02	.0	1.000E+00	-2.993E+02	3.882E-01	7.870E-02	-9.704E-02	-1.205E-01	-1.565E-01	
				4.740E-02	.0	.0	.0				
19	9.159E+02	7.951E+02	.0	1.000E+00	-3.854E+02	4.229E-01	4.383E-01	-1.395E-01	-1.382E-02	-2.624E-01	
				6.057E-03	.0	.0	.0				
20	9.724E+02	7.951E+02	.0	1.000E+00	-4.419E+02	4.459E-01	6.912E-01	-1.607E-01	9.807E-02	-3.187E-01	
				-8.348E-03	.0	.0	.0				
21	8.613E+02	9.265E+02	.0	1.000E+00	-3.308E+02	5.779E-01	2.677E-02	1.996E-01	-1.175E-01	-1.438E-01	
				-3.267E-01	.0	.0	.0				
22	9.268E+02	9.265E+02	.0	1.000E+00	-3.963E+02	6.077E-01	3.305E-01	1.966E-01	4.356E-02	-1.514E-01	
				-2.746E-01	.0	.0	.0				
23	1.001E+03	9.265E+02	.0	1.000E+00	-4.708E+02	6.430E-01	6.839E-01	2.030E-01	2.504E-01	-1.221E-01	
				-1.237E-01	.0	.0	.0				
24	1.050E+03	9.265E+02	.0	1.000E+00	-5.193E+02	6.668E-01	9.197E-01	2.137E-01	4.018E-01	-7.494E-02	
				4.832E-02	.0	-3.164E+01	.0				
25	9.462E+02	1.032E+03	.0	1.000E+00	-4.146E+02	7.707E-01	3.234E-01	5.372E-01	2.187E-01	1.456E-01	
				-2.698E-01	.0	.0	.0				
26	1.004E+03	1.032E+03	.0	1.000E+00	-4.773E+02	8.004E-01	6.097E-01	5.627E-01	4.209E-01	2.491E-01	
				6.356E-03	.0	.0	.0				
27	1.070E+03	1.032E+03	.0	1.000E+00	-5.39[illegible]E+02	8.348E-01	9.413E-01	5.966E-01	6.690E-01	3.978E-01	
				4.287E-01	.0	.0	.0				
28	1.112E+03	1.032E+03	.0	1.000E+00	-5.819E+02	8.572E-01	1.158E+00	6.204E-01	8.338E-01	5.028E-01	
				7.169E-01	.0	-2.867E+01	.0				
29	1.008E+03	1.110E+03	.0	1.000E+00	-4.781E+02	9.211E-01	5.807E-01	8.590E-01	6.023E-01	6.331E-01	
				2.356E-01	.0	.0	.0				
30	1.061E+03	1.110E+03	.0	1.000E+00	-5.301E+02	9.490E-01	8.474E-01	8.921E-01	8.129E-01	7.805E-01	
				6.362E-01	.0	.0	.0				
31	1.120E+03	1.110E+03	.0	1.000E+00	-5.891E+02	9.804E-01	1.152E+00	9.288E-01	1.059E+00	9.568E-01	
				1.167E+00	.0	.0	.0				
32	1.158E+03	1.110E+03	.0	1.000E+00	-6.278E+02	1.001E+00	1.353E+00	9.529E-01	1.221E+00	1.076E+00	
				1.528E+00	.0	-2.654E+01	.0				
33	1.047E+03	1.158E+03	.0	1.000E+00	-5.162E+02	1.015E+00	7.470E-01	1.073E+00	8.706E-01	1.006E+00	
				6.782E-01	.0	.0	.0				
34	1.095E+03	1.158E+03	.0	1.000E+00	-5.647E+02	1.041E+00	9.981E-01	1.104E+00	1.073E+00	1.152E+00	
				1.119E+00	.0	.0	.0				
35	1.150E+03	1.158E+03	.0	1.000E+00	-6.199E+02	1.070E+00	1.284E+00	1.138E+00	1.305E+00	1.318E+00	
				1.632E+00	.0	.0	.0				
36	1.196E+03	1.158E+03	.0	1.000E+00	-6.558E+02	1.089E+00	1.470E+00	1.160E+00	1.455E+00	1.426E+00	
				1.967E+00	.0	.0	.0				

OUTPUT POINT LOCATIONS ARE SHIFTED LOCAL COORDINATES

NOW	X	Y	Z	SLOPE DZ/DX					
1	1.578E+02	9.690E+01	.0	.0	-9.758E-01	-9.467E-05	-3.651E-05	2.637E-05	8.791E-05	-2.114E-05
				1.802E-05	.0	.0	.0			
2	3.340E+02	9.690E+01	.0	.0	-9.828E-01	-8.263E-05	-3.009E-05	-3.675E-06	1.061E-04	3.015E-05
				-5.170E-05	.0	.0	.0			
3	5.343E+02	9.690E+01	.0	.0	-9.447E-01	-1.161E-04	3.250E-05	4.852E-05	-4.622E-04	-2.883E-05
				7.269E-05	.0	.0	.0			
4	6.651E+02	9.690E+01	.0	.0	-9.470E-01	-4.306E-05	3.297E-05	-9.875E-05	-1.668E-04	1.951E-04
				-2.350E-04	.0	.0	.0			
5	3.186E+02	2.882E+02	.0	.0	-7.209E-01	-9.851E-05	4.803E-06	6.372E-05	-2.633E-04	-6.184E-05
				8.652E-05	.0	.0	.0			
6	4.614E+02	2.882E+02	.0	.0	-9.943E-01	2.195E-05	9.537E-05	-2.452E-04	-3.619E-04	4.101E-04
				-4.539E-04	.0	.0	.0			
7	6.238E+02	2.882E+02	.0	.0	-9.986E-01	5.166E-05	5.419E-04	-4.874E-04	-2.925E-03	8.865E-04
				-8.219E-04	.0	.0	.0			
8	7.298E+02	2.882E+02	.0	.0	-1.023E+00	9.596E-05	9.367E-04	-7.061E-04	-5.158E-03	1.244E-03
				-1.024E-03	.0	.0	.0			
9	4.728E+02	4.716E+02	.0	.0	-9.906E-01	1.087E-04	2.446E-04	-3.702E-04	-1.453E-03	5.417E-04
				-4.214E-04	.0	.0	.0			
10	5.836E+02	4.716E+02	.0	.0	-9.918E-01	1.529E-04	5.782E-04	-5.304E-04	-3.501E-03	8.140E-04
				-5.541E-04	.0	.0	.0			
11	7.096E+02	4.716E+02	.0	-.0	-9.935E-01	2.112E-04	7.586E-04	-6.266E-04	-4.602E-03	8.792E-04
				-6.848E-04	-1.000E+00	-.0	-.0			
12	7.918E+02	4.716E+02	.0	-.0	-9.935E-01	2.112E-04	7.586E-04	-6.266E-04	-4.602E-03	8.792E-04
				-6.848E-04	-1.000E+00	-.0	-1.000E+00			
13	6.291E+02	6.421E+02	.0	.0	-9.999E-01	4.411E-04	6.167E-04	-3.043E-04	-5.408E-03	3.772E-04
				-2.338E-04	.0	.0	.0			
14	7.110E+02	6.421E+02	.0	.0	-1.000E+00	3.754E-04	1.668E-03	-6.671E-04	-3.654E-03	-2.604E-04
				3.593E-04	.0	.0	.0			
15	8.143E+02	6.421E+02	.0	.0	-1.000E+00	3.576E-04	2.585E-03	-8.207E-04	-2.003E-03	-8.740E-04
				6.665E-04	.0	.0	.0			
16	8.818E+02	6.421E+02	.0	.0	-9.998E-01	3.936E-04	2.851E-03	-7.090E-04	-1.556E-03	-1.058E-03
				4.852E-04	.0	.0	.0			
17	7.535E+02	7.951E+02	.0	.0	-1.001E+00	4.864E-04	2.280E-03	-3.219E-04	-2.799E-03	-6.363E-04
				-2.410E-04	.0	.0	.0			

OUTPUT POINT LOCATIONS ARE SHIFTED LOCAL COORDINATES

ROW	X	Y	Z	SLOPE DZ/DY						
1	1.578E+02	9.699E+01	.0	.0 2.978F-04	2.211E-01 .0	-2.986E-05 .0	-4.619E-05 .0	1.273E-04	9.076E-05	-2.506E-04
2	3.940E+02	9.690E+01	.0	.0 -1.294E-04	1.856F-01 .0	4.745E-05 .0	-2.187E-05 .0	-5.673E-05	5.122E-04	7.672E-05
3	5.343E+02	9.690E+01	.0	.0 -8.760E-05	-6.092F-02 .0	5.823E-06 .0	3.532E-05 .0	-4.095E-05	-1.848E-04	7.982F-05
4	6.651E+02	9.690F+01	.0	.0 -1.880E-04	1.234E-01 .0	1.119E-04 .0	-1.430E-04 .0	-1.275E-04	1.256E-03	1.031E-04
5	3.196E+02	2.882E+02	.0	.0 3.287F-04	4.828F-01 .0	2.218E-05 .0	-1.878E-04 .0	1.343F-04	1.097E-03	-3.014E-04
6	4.614E+02	2.882E+02	.0	.0 -1.907E-04	1.374F-01 .0	1.791E-04 .0	-2.105E-04 .0	-1.959E-04	1.772E-03	1.285F-04
7	6.230E+02	2.882E+02	.0	.0 -2.131E-04	-1.678E-02 .0	2.044E-04 .0	-6.332E-05 .0	-4.030F-04	9.535E-04	3.370E-04
8	7.290E+02	2.882E+02	.0	.0 -2.561F-04	-4.452E-02 .0	3.578E-04 .0	2.114E-04 .0	-5.798E-04	-6.968E-04	5.596E-04
9	4.728E+02	4.716E+02	.0	.0 5.076E-04	-3.683E-03 .0	3.795E-04 .0	-6.671E-04 .0	-1.533E-04	6.008E-03	-3.319E-04
10	5.836E+02	4.716E+02	.0	.0 6.869E-04	-7.594E-03 .0	4.605E-04 .0	-5.975E-04 .0	-2.036E-04	5.268E-03	-3.512E-04
11	7.096E+02	4.716E+02	.0	.0 7.413E-04	5.134E-03 .0	5.553E-04 .0	-6.395E-04 .0	-1.916E-04	1.934E-03	-2.741E-04
12	7.918E+02	4.716E+02	.0	.0 9.940E-04	-6.514E-03 .0	6.288E-04 .0	-6.623E-04 -8.761E-16	-2.004E-04	1.878F-03	-4.538E-04
13	6.291E+02	6.421E+02	.0	.0 4.044E-04	-5.306E-04 .0	9.612E-04 .0	-2.076E-03 .0	7.620E-04	-7.442E-04	-3.740E-04
14	7.110E+02	6.421F+02	.0	.0 1.037E-03	-7.656E-04 .0	8.539E-04 .0	-8.927E-04 .0	3.643E-04	1.151E-03	-1.084E-03
15	8.143E+02	6.421F+02	.0	.0 9.943E-04	-7.949E-04 .0	9.296E-04 .0	-3.177E-04 .0	4.177F-04	2.095E-03	-1.581E-03
16	8.818E+02	6.421F+02	.0	.0 3.446E-04	-5.217E-04 .0	1.037E-03 .0	-5.944E-04 .0	8.128F-04	1.406E-03	-1.375F-03
17	7.535E+02	7.951E+02	.0	.0 -9.564F-04	-2.630F-03 .0	1.216E-03 .0	-1.988E-03 .0	1.532E-03	-1.377E-03	-4.913F-04

18	8.295E+02	7.951E+02	.0	.0 -3.931E-04	-9.992E-01 .0	4.416E-04 .0	3.553E-03 .0	-4.132E-04	-1.195E-04	-1.079E-03
19	8.159E+02	7.951E+02	.0	.0 -4.285E-04	-9.978E-01 .0	3.761E-04 .0	4.570E-03 .0	-4.971E-04	2.182E-03	-1.245E-03
20	9.724E+02	7.951E+02	.0	.0 8.715E-05	-1.001E+00 .0	4.286E-04 .0	4.464E-03 .0	-2.737E-04	1.968E-03	-7.764E-04
21	8.613E+02	9.265E+02	.0	.0 2.263E-04	-9.999E-01 .0	4.455E-04 .0	4.578E-03 .0	-1.089E-04	2.303E-03	-3.385E-04
22	9.268E+02	9.265E+02	.0	.0 1.472E-03	-9.999E-01 .0	4.678E-04 .0	4.701E-03 .0	4.312E-05	2.649E-03	1.919E-04
23	1.071E+03	9.265E+02	.0	.0 2.731E-03	-9.999E-01 .0	4.810E-04 .0	4.799E-03 .0	1.499E-04	2.944E-03	6.453E-04
24	1.050E+03	9.265E+02	.0	-.0 3.379E-03	-1.000E+00 -.0	4.853E-04 -8.489E-01	4.833E-03 -.0	1.850E-04	3.054E-03	8.635E-04
25	9.462E+02	1.032E+03	.0	.0 4.050E-03	-9.998E-01 .0	5.118E-04 .0	4.923E-03 .0	4.155E-04	3.190E-03	1.606E-03
26	1.004E+03	1.032E+03	.0	.0 5.832E-03	-9.999E-01 .0	5.228E-04 .0	5.018E-03 .0	5.060E-04	3.493E-03	2.137E-03
27	1.070E+03	1.032E+03	.0	.0 7.163E-03	-9.994E-01 .0	5.268E-04 .0	5.082E-03 .0	5.555E-04	3.899E-03	2.502E-03
28	1.112E+03	1.032E+03	.0	-.0 7.826E-03	-9.990E-01 -.0	5.294E-04 -8.489E-01	5.078E-03 -.0	5.674E-04	3.890E-03	2.504E-03
29	1.008E+03	1.110E+03	.0	.0 7.312E-03	-1.001E+00 .0	5.351E-04 .0	5.106E-03 .0	6.171E-04	3.982E-03	2.706E-03
30	1.061E+03	1.110E+03	.0	.0 7.983E-03	-1.000E+00 .0	5.335E-04 .0	5.135E-03 .0	6.355E-04	4.077E-03	2.881E-03
31	1.120E+03	1.110E+03	.0	.0 1.011E-02	-9.999E-01 .0	5.273E-04 .0	5.202E-03 .0	5.825E-04	4.243E-03	3.033E-03
32	1.158E+03	1.110E+03	.0	-.0 9.355E-03	-9.999E-01 -.0	5.303E-04 -8.489E-01	5.179E-03 -.0	6.128E-04	4.195E-03	3.021E-03
33	1.047E+03	1.158E+03	.0	.0 8.161E-03	-9.999E-01 .0	5.357E-04 .0	5.146E-03 .0	6.689E-04	4.128E-03	3.024E-03
34	1.095E+03	1.158E+03	.0	-.0 9.489E-03	-9.999E-01 -.0	5.304E-04 -.0	5.185E-03 -.0	6.143E-04	4.211E-03	3.045E-03
35	1.150E+03	1.158E+03	.0	-.0 9.489E-03	-9.999E-01 -.0	5.304E-04 -.0	5.185E-03 -.0	6.143E-04	4.211E-03	3.045E-03
36	1.186E+03	1.158E+03	.0	-.0 9.489E-03	-9.999E-01 -.0	5.304E-04 -.0	5.185E-03 -.0	6.143E-04	4.211E-03	3.045E-03

18	8.2995E+02	7.9515E+02	.0	.0 -4.9128E-03	3.3968E-03 .0	1.2068E-03 .0	-1.4367E-03 .0	1.8498E-03	-4.3259E-04	-3.8418E-04
19	9.1598E+02	7.9515E+02	.0	.0 -2.7758E-03	3.3718E-03 .0	1.2878E-03 .0	-1.0944E-03 .0	2.1508E-03	3.8077E-04	-8.1119E-05
20	9.7246E+02	7.9515E+02	.0	.0 -2.1922E-03	-6.4038E-04 .0	1.3644E-03 .0	-1.3056E-03 .0	2.4656E-03	-5.0736E-05	5.7056E-04
21	8.4135E+02	9.2655E+02	.0	.0 -2.4128E-03	1.7005E-04 .0	1.3886E-03 .0	-1.1796E-03 .0	2.7066E-03	3.2768E-04	1.1771E-03
22	9.2688E+02	9.2655E+02	.0	.0 -1.2198E-03	2.0578E-04 .0	1.4196E-03 .0	-1.0488E-03 .0	2.9326E-03	7.4622E-04	1.8806E-03
23	1.0018E+03	9.2655E+02	.0	.0 -6.4146E-05	2.1158E-04 .0	1.4408E-03 .0	-9.4268E-04 .0	3.0998E-03	1.0848E-03	2.4928E-03
24	1.0508E+03	9.2655E+02	.0	.0 1.8518E-03	1.2656E-04 .0	1.4656E-03 5.2846E-01	-8.0278E-04 .0	3.3118E-03	1.5428E-03	3.3578E-03
25	9.4628E+02	1.0328E+03	.0	.0 6.6528E-04	2.7998E-04 .0	1.4878E-03 .0	-8.1178E-04 .0	3.5078E-03	1.6058E-03	3.7388E-03
26	1.0048E+03	1.0328E+03	.0	.0 2.1778E-03	4.9628E-04 .0	1.5068E-03 .0	-7.1148E-04 .0	3.6708E-03	1.9548E-03	4.4368E-03
27	1.0708E+03	1.0328E+03	.0	.0 3.2228E-03	7.6388E-04 .0	1.5188E-03 .0	-6.4768E-04 .0	3.7968E-03	2.1848E-03	4.9218E-03
28	1.1128E+03	1.0328E+03	.0	.0 4.4338E-03	6.5458E-04 .0	1.5228E-03 5.2868E-01	-5.8338E-04 .0	3.8458E-03	2.3928E-03	5.3208E-03
29	1.1088E+03	1.1108E+03	.0	.0 3.7118E-03	-2.6678E-03 .0	1.5328E-03 .0	-6.1568E-04 .0	3.8778E-03	2.2628E-03	5.2078E-03
30	1.0618E+03	1.1108E+03	.0	.0 3.0478E-03	-3.0578E-03 .0	1.5368E-03 .0	-5.8378E-04 .0	3.9368E-03	2.4048E-03	5.4668E-03
31	1.1208E+03	1.1108E+03	.0	.0 4.0928E-03	-3.2578E-03 .0	1.5378E-03 .0	-5.3778E-04 .0	3.9458E-03	2.5428E-03	5.6908E-03
32	1.1988E+03	1.1108E+03	.0	.0 4.8618E-03	-3.4878E-03 .0	1.5418E-03 5.2862E-01	-5.3018E-04 .0	3.9908E-03	2.5868E-03	5.8348E-03
33	1.0478E+03	1.1588E+03	.0	.0 2.5768E-03	-3.1508E-03 .0	1.5478E-03 .0	-6.0518E-04 .0	4.0478E-03	2.4048E-03	5.6768E-03
34	1.0958E+03	1.1588E+03	.0	.0 3.9788E-03	-3.2308E-03 .0	1.5418E-03 .0	-5.8348E-04 .0	3.9978E-03	2.4948E-03	5.7088E-03
35	1.1508E+03	1.1588E+03	.0	.0 3.9788E-03	-3.2308E-03 .0	1.5418E-03 .0	-5.8348E-04 .0	3.9928E-03	2.4948E-03	5.7088E-03
36	1.1968E+03	1.1588E+03	.0	.0 3.9788E-03	-3.2308E-03 .0	1.5418E-03 .0	-5.8348E-04 .0	3.9928E-03	2.4948E-03	5.7088E-03

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1 Report No.	2 Government Accession No.	3 Recipient's Catalog No.
NASA CR-2847		

4 Title and Subtitle	5 Report Date
MODAL INTERPOLATION PROGRAM, L215 (INTERP) Volume I: Engineering and Usage	October 1979
	6 Performing Organization Code
7 Author(s) R. I. Kroll and M.Y. Hirayama	8 Performing Organization Report No. D6-44456
9 Performing Organization Name and Address Boeing Commercial Airplane Company P.O. Box 3707 Seattle, Washington, 98124	10 Work Unit No.
	11 Contract or Grant No. NAS1-13918
12 Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	13 Type of Report and Period Covered May 1975 to May 1977
	14 Sponsoring Agency Code

15 Supplementary Notes
Langley Technical Monitors: Robert C. Goetz and Boyd Perry III
Topical Report

16 Abstract

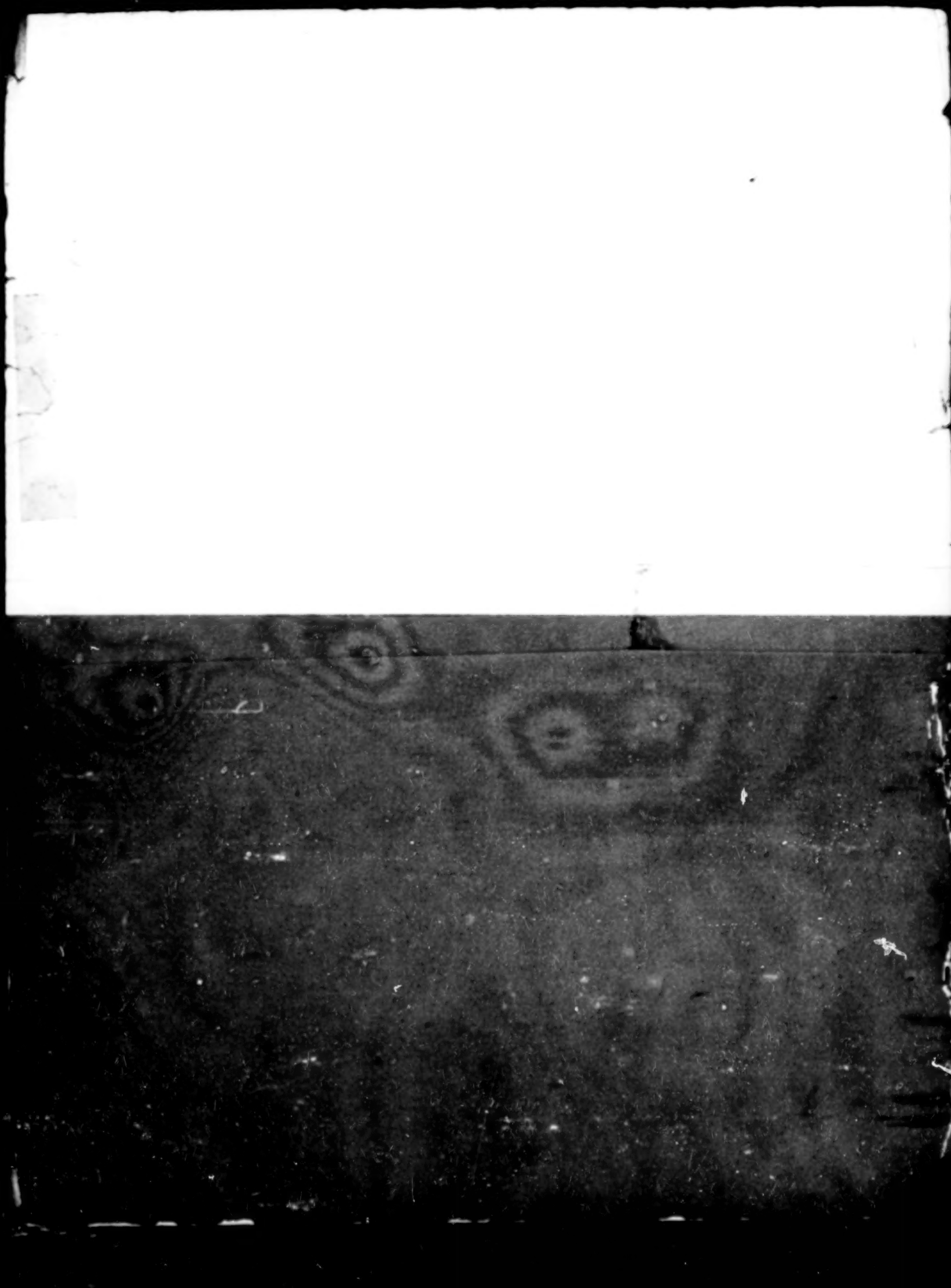
This document describes the usage of the Modal Interpolation Program L215 (INTERP). The program uses modal data to form sets of arrays containing interpolation coefficients. The interpolation arrays can then be used to determine displacements at various aerodynamic control points. The displacements consist of translations normal to the aerodynamic surface and surface slopes that are parallel and perpendicular to the freestream direction. Five different interpolation methods are available. A description of the data manipulation and the interpolation methods is presented in volume I of this document. Volume II contains a description of the design and structure of the program to aid those who will maintain and/or modify the program in the future.

17 Key Words (Suggested by Author(s))	18 Distribution Statement
Modal interpolation Beam spline Motion axis Surface spline Motion point Polynomial interpolation	Unclassified - Unlimited Subject Category 02

19 Security Classif. (of this report)	20 Security Classif. (of this page)	21 No. of Pages	22 Price*
Unclassified	Unclassified	118	$6.50

*For sale by the National Technical Information Service, Springfield, Virginia 22151

NASA-Langley, 1979



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June 17, 1981